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TRANSACTIONS

OF THE

MANCHESTER

GEOLOGICAL SOCIETY.

VOL. IX.—PART I.

LONDON:
SIMPKIN, MARSHALL, & CO.
AND "THE MINING JOURNAL" OFFICE, 26, FLEET STREET
MANCHESTER:
JOHN HEYWOOD, 141 & 143, DEANSGAT
MDCCCLXX.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 1.] VOL. IX. [Session 1869-70.

At the Annual Meeting of the Society held at the Peter Street Museum, October 27th, 1869.

G. C. GREENWELL, ESQ., President, in the Chair.

Messrs. ORMEROD, ASHWORTH, DICKINSON, PLANT, J. KNOWLES, T. LIVESEY, DAWKINS, WILD, GRIMSHAW, CHARLTON, and C. LIVESEY were present.

The following Report was read:—

REPORT OF THE COUNCIL.

The Council, which has had the direction of your affairs during the past year, in bringing its duties to a close, begs to report that in the period very little has been done to promote the objects for which the Society was formed. Only two papers have been added to the transactions. This temporary decline in the number of contributors is doubtless due to the anxious feeling which has existed amongst the members, caused by the unsettled state of the arrangements for the accommodation of the Collection and future Meetings of the Society.

This has been the principal topic discussed by your Council, which has given its most careful attention to the subject. The Members of your Council were extremely anxious to keep the Collection in some central position where the meetings of the Society could likewise be held. Every scheme that suggested itself was examined, but the difficulties in the way appeared insuperable. After mature considera-

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tion, it was concluded that the best interests of the Society would be consulted if an arrangement were made with the Extension Committee of Owens College similar to the one they had made with the Natural History Society. A provisional agreement was prepared and presented to a Special General Meeting held on the 14th of September last. This meeting took the same view, and if a Second Meeting, to be held on the 30th of November next, confirms the agreement, the future of your Collection may be looked upon as settled.

It will remain for a future Council to make suitable provision for a meeting-room and library. The subject is, however, not of immediate importance, as for two or three years the present rooms will be available.

It is to be hoped, now that the Society's affairs are becoming more settled, that increased activity will prevail, and that Members will endeavour to make the next session a more useful and interesting one than the last has been.

No excursion has been undertaken.

Two new members have been elected; eight have resigned, or ceased to be members; and two have died.

The Treasurer's Report, which is appended, shows that, financially, the Society is in a satisfactory state.

THE FOLLOWING ADDITIONS TO THE PUBLISHED TRANSACTIONS HAVE BEEN MADE :—

1. Address of the President, G. C. GREENWELL, ESQ., F.G.S.
2. Papers read in 1842-3 reprinted.
3. Economical Working of Coal Mines. BY MR. J. WARBURTON.
4. On Productus Llangollensis, from the Eglwseg Rocks, Llangollen North Wales. Mr. John Aitken.

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New Members Elected, 1869-70.

W. Boyd Dawkins, Esq., F.R.S., F.G.S. | Dr. Alcock.

Deceased Members.

Mr. Joseph Roscow, | Mr. James Hardcastle.

Members who have Resigned.

Mr. S. B. Sutcliffe,
Mr. G. B. Forster,
Mr. R. Pease,
Mr. G. Pease,
Mr. J. G. Blackburn,
Mr. T. Marquis,
Mr. G. Kearsley,
Mr. Henry Jackson.

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MANCHESTER GEOLOGICAL SOCIETY.

BALANCE SHEET,—1869.

ABSTRACT OF RECEIPTS.

1868-9.	£	s.	d.
To Balance brought down	149	13	4
„ Subscriptions, 1868-9	100	0	0
„ Arrears of former years	3	0	0
„ Interest from the Bank	1	19	0
„ Dividends on Birkenhead Stock	13	13	4
„ Cash Sale of Proceedings	14	17	9
	£283	3	5

R. D. DARBISHIRE, AUDITOR.

19th November, 1869.

ABSTRACT OF PAYMENTS.

1869.	£	s.	d.
By Library	6	6	6
„ Reports of Meetings	23	0	3
„ Reporters	9	9	9
„ Printing and Stationery	5	15	9
„ Postage and Delivery of Proceedings, &c.	20	13	0
„ Collector's Commission	5	3	0
„ Gratuity to Mr. Parker	5	5	0
„ Insurance	0	3	0
„ Wages of Assistant Curator	12	5	0
„ Purchase of £100 Birkenhead Stock	94	12	6
	182	13	9
„ Balance in Bank	100	9	8
	£283	3	5

HENRY M. ORMEROD, TREASURER.

26th October, 1869.

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Mr. Plant asked for some information as to the item for Assistant Curator.

Mr. Ormerod gave the necessary explanation.

Mr. Plant entered a protest against the reprinting of the papers read during the Session of 1842-3. He said that some of the writers were dead, and that he felt certain that others of them would not be pleased to find that opinions they held between twenty and thirty years ago should be brought again before the public after so many things had been discovered to modify their views. He considered it a waste of the Society's money.

Mr. Dickinson joined in the protest.

Mr. J. Knowles moved, Mr. Dickinson seconded, and the meeting resolved:—"That the Report and Accounts be received, adopted, and printed as usual."

The next business being the Election of Officers for the ensuing year, it was moved by Mr. Ormerod, seconded by Mr. Dawkins, and resolved:—"That as Messrs. Dickinson and Plant objected to a list being presented to the Society of Members eligible to fill the various offices, that each office shall be taken *seriatim*, and members be proposed and elected to fill them."

Mr. Ormerod proposed that Mr. John Aitken be elected President for the ensuing year; Mr. T. Livesey seconded the motion, and it was carried unanimously.

Moved by Mr. Ormerod, seconded by Mr. John Knowles, and resolved:—"That Mr. John E. Forbes, F.G.S., be elected a Vice-President."

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OFFICERS AND COUNCIL FOR 1869-70.

President:

JOHN AITKEN, Esq., F.G.S

Vice-Presidents:

G. C. GREENWELL, Esq., F.G.S

JOHN KNOWLES, Esq.

THOMAS LIVESEY, Esq.

JOHN E. FORBES, Esq., F.G.S

Treasurer:

HENRY MERE ORMEROD, Esq.

Auditors:

R. P. GREG, Esq., F.G.S. | R. D. DARBISHIRE, Esq., F.G.S.

Honorary Secretaries:

F. P. CHARLTON, Esq. | C. LIVESEY, Esq.

Honorary Curators:

A. KNOWLES, Esq. | E. W. BINNEY, Esq., F.R.S., F.G.S.

Other Members of the Council:

Mr. J. Ashworth,
„ J. Chattwood,
„ J. Dickinson,
„ C. Hardwicke,
„ Alderman Harvey.
„ George Gilroy.
Mr. John Wild,
„ G. S. F. Smith,
„ James Eccles,
Dr. Alcock,
Mr. S. Crowther,
„ William Bryham.

A cordial vote of thanks to the President for his services during the past year was carried unanimously.

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On Productus Llangollensis, from the Eglwseg Rocks, Llangollen, North Wales.

READ MAY 25TH, 1869, BY MR. JOHN AITKEN.

The specimens of Productus Llangollensis submitted for examination were obtained by me during a recent visit to Llangollen, from a bed of black calcareous shale near the base of the lower Carboniferous limestone at the Eglwseg Rocks, Llangollen, where they are found in great abundance.

The bed of shale in question is about three feet in thickness, of a dark grey colour and fine texture. Throughout the entire body of these shales, the shells are profusely distributed, without any apparent order or stratification, and lie in various positions and at all angles; the margins of the shells are frequently broken, a circumstance which Mr. Davies, of Oswestry (who has paid considerable attention to the Carboniferous limestone of North Wales, and its contained organic remains), considers furnishes evidence of their having been drifted from a distance to their present resting-place.

I, however, entertain serious doubts as to the correctness of this inference, having failed to discover the least trace of attrition on the surfaces of the shells, the indications of which must inevitably have been left had they been subjected to the action of a current of water sufficiently powerful, not only to overcome the resistance to motion presented by heavy bulky bodies, but also to have violently fractured these immensely strong and massive shells.

I would rather look to the pressure to which the soft, yielding, muddy matrix was subjected subsequent to the entombment of the fossils, in consequence of the gradual accumulation of the superincumbent mass of Carboniferous limestone, as a probable explanation of their being so frequently found in a broken state.

The genus in which these shells should be included has long been a moot question among palæontologists, some classing them as Productus, others placing them amongst the Chonetes, most authorities, however, agreeing in the latter classification: even Mr. Davidson,

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although with some lingering doubt, concurred in that arrangement, being led to this conclusion principally from the presence of two strong articulating hinge teeth, and the absence of examples of the interior structure of the dorsal valve in the specimens originally submitted to him for examination. By the persevering efforts of Mr. Davies, specimens were subsequently obtained from the Eglwseg rocks, which supplied the necessary information for determining satisfactorily their true generic position. In consequence of which Mr. Davidson has now finally classed them with the genus Productidæ.

The presence of the two articulating hinge teeth, in combination with other characteristics pertaining to Productidæ was long a source of difficulty and perplexity with palæontologists in determining the genus of these shells—the teeth being considered as conclusive evidence of their belonging to the sub-genus Chonetes. It has, however, more recently been found necessary to abandon this mark as a distinctive characteristic of that genus, since teeth of this character have been found in three or four undoubted species of Producti. It will thus be seen that these shells share the character of both Chonetes and Productidæ, but, as now ascertained, bear the structure and form of the latter in a much greater degree than the former; hence their final classification with the genus Productidæ.

By glancing at the specimens submitted for inspection, it will be noticed that the shells of Productus Llangollensis, when full-grown, attain a large size; they are nearly circular in form, and have straight hinge lines. The ventral valves are very ponderous, reaching in adult specimens to about one inch in thickness, the beak is rounded and well developed, and on each side of the fissure are two strong projecting teeth.

The dorsal valve is comparatively thin and fragile, hence it is a somewhat rare occurrence to secure a specimen with this valve attached. Both the valves are finely striated.

From the character of the strata in which the fossils are embedded at the Eglwseg Rocks, the shells are found in a beautiful state of preservation; the interior muscular impressions in those specimens where the shale has weathered out by the action of the atmosphere, being almost as distinct and sharp as when first buried in the enclosing

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matrix. These fossils are found in several other localities, but so far as I have been able to ascertain, in no other instance are they obtained in equal abundance, nor yet of so interesting a character as at the place here mentioned. A visit, therefore, to the Eglwseg Rocks, independently of the charming scenery and the fine natural features of one of the most lovely spots in the Principality, would amply repay any one interested in studying the fauna of that important sub-division of the Carboniferous rocks to which the mountain limestone belongs.

DESCRIPTION OF THE FOSSILS EXHIBITED.

No. 1. Showing the interior of structure of the ventral valve, with the muscular impressions, &c.

No. 2. A full-grown specimen, showing the thickness of the shell of the ventral valve.

No. 3. Ventral valve, with cast of interior.

No. 4. A young specimen, showing considerable variation in form from the adult shell, particularly in the hinge line.

No. 5. Specimen showing ventral and dorsal valve in natural position.

The Monthly Meeting of the Members of the Manchester Geological Society was held at the Museum, Peter Street, on Tuesday, the 30th November, 1869—

JOHN AITKEN, Esq., F.G.S., President, in the chair, who delivered the following inaugural address :—

In assuming to-day the position of President of the Manchester Geological Society, which by your kindness I have been called upon to occupy, allow me in the first place to express my grateful acknowledgement to the members for this expression of their confidence, and the honour thus conferred upon me.

Whilst, however, feeling deeply sensible of the kindness and confidence thus evinced towards me, I can not overlook the great responsibilities attaching to the office, nor yet fail to realise the fact that from want of experience and other causes I shall have to make frequent claims upon your forbearance and kind consideration whilst

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conducting the business of the society during the ensuing year. It will, nevertheless, be my earnest endeavour whilst occupying this chair to discharge the duties of the office, to the best of my ability, with fairness and impartiality, looking earnestly to the advancement of science and the welfare of the society. Being guided by these principles, I trust I may be allowed to indulge in the hope that, with your co-operation and assistance, the session upon which we are this day entering may be productive of results beneficial alike to the society as a body, and to each individual member associated therewith.

It has now been the custom for some time past to inaugurate the proceedings of the session by an address from the chair, setting forth the position and prospects of the society, together with such other observations of a scientific or more general character as circumstances should require or fancy dictate. In the present instance, although feeling considerable hesitation in accepting so responsible a duty, I have not ventured to depart from a practice now sanctioned by several years' observance. I shall therefore, in the present instance, solicit your attention whilst submitting for your consideration the following remarks.

It is a source of regret to the Council that, in consequence of the anomalous and unsatisfactory position in which this Society has unfortunately been placed, owing to the decision arrived at by the managing body of the Natural History Society, to transfer their entire collection, together with the Museum buildings, in which accommodation has been provided for the use of this society during the last eighteen years, to the Commissioners for the Extension of Owens College, for the ultimate use and benefit of that educational establishment; and the uncertainty which has prevailed as to its ultimate destiny, a state of langour and want of interest have characterised its proceedings during the past year. This want of activity has been manifest in all the operations of the society. Its chilling effects have, however, been most marked in the falling-off in the number of papers read during the session just closed. This will be rendered apparent by instituting a comparison of the number of communications contributed during the past three years. In the session of 1866-7, twelve were read; in 1867-8, fourteen were read; whilst in the session just closed only two, in addition to the presidential address,

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were brought before the Society. One of these was upon some specimens of *Productus Llangollensis*, obtained at Llangollen by myself; and the other was contributed by Mr. John Warburton, and treated of the "Economical Working of Coal Mines"—a subject of the greatest importance and interest to a community like ours, so extensively engaged in this branch of industry, and whose success so largely depends upon a cheap and abundant supply of fuel. The paper abounded in practical and valuable suggestions, and evinced the possession by the author of a thorough knowledge of coal mining in all its details; indeed, so lively an interest was manifested in this subject, as to call for the necessity of appropriating a subsequent meeting to its fuller consideration, when an interesting and animated discussion took place. I would therefore hope that the interest taken in this paper will prove an incentive to those of our members who are more immediately connected with mining operations, so that, during the ensuing session, we may be favoured with other contributions on kindred subjects connected with that important branch of industry.

From the time when the Council of the Natural History Society decided upon disposing of their property in the way above indicated, it became apparent to those who took an active interest in the concerns of this society, that in consequence of the intimate arrangements existing between the two societies, and the joint character of the geological and mineralogical collections, that it would be necessary forthwith to take into consideration the position of the society, with the view of devising a scheme whereby its establishment upon a satisfactory and permanent basis might be secured; and at the same time, that the advantages derived from the extensive and valuable collection, which has taken years of patient industry and perseverance, and at very considerable expenditure of money, to get together and arrange, might not be lost to the society, and to the inhabitants of this important city and the populous district surrounding it.

In furtherance of this object a committee was appointed, who have had under consideration various schemes, suggested with the view of keeping the collection in the hands of the society, and placing it in some central part of the city, easy of access, and where accommodation might also be provided for holding the meetings; all of which schemes, however, it was found necessary to abandon in consequence of the

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difficulties which subsequently presented themselves; and the committee eventually came to the unanimous conclusion that the best interests of the society would be consulted by recommending a similar disposition of the collection to that which had taken place with regard to the Natural History Society. These recommendations have (by the vote which you have passed to-day) received the sanction of two Special General Meetings, and now only await the final act of handing over the property to the new authorities when the proper time shall arrive. I need not refer to the conditions of that arrangement further than to say, that it embraces a scheme for transferring, as a free gift, the whole of the collection belonging to this society to commissioners for the ultimate use and benefit of Owens Enlarged College; the said commissioners undertaking to find convenient and commodious rooms for its reception, together with provision for its permanent maintenance as one entire collection, free to the use of members of this society, and other students, for scientific purposes, on five days, and to the public, free of charge, on three days in each week.

Although regretting that by this arrangement the Museum will, of necessity, be removed to some distance from the centre of the city, it is satisfactory to know that its permanence and means of usefulness are secured; and we have reason to hope and believe that it will take its place as the most complete and important institution of this character in the north of England: it has also this further advantage, that by the removal of the responsibility and expense of maintaining the Museum, the whole of the energies and means at the disposal of the society can be more effectually concentrated in furthering the objects for which it was established, and which it is endeavouring to attain. I would therefore express a hope, now the difficulties which have beset the society for some time past have been tided over, that each member will nerve himself to the work, and exhibit by his personal interest and activity, a determination not to be content with a lower position for this society, situated, as it is, in the midst of a numerous, energetic, and wealthy population, than that of equality with the most successful provincial associations in Great Britain.

This object may be attained, amongst other means, by a vigilant observation of facts as they occur in our several localities; for, although by no means ignoring the value of questions of more general interest,

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I conceive that the especial province of a provincial society like ours consists in the first instance in directing its attention to the elucidation of the geology of the district in which it is situated, so that its transactions may embrace a complete record of its detailed physical structure and fossil remains, of every discovery of interest, and of all facts tending to throw light upon the subject to which its energies are directed.

Few fields offer a better opportunity for varied geological research than that presented by our own county. Within its borders we have an almost unbroken series of strata, extending from the Lower Silurian formation represented by the green slates and porphyries of the N.W. of Furness, to the upper members of the trias of Manchester and Liverpool, upon which reposes over the greater portion of its surface, up to an elevation of about a thousand feet, a thick mantle of drift, in some places abounding in characteristic organic remains, particularly on its western border near Blackpool, and in the depressions and valleys of whose surface again rest the more recent accumulations consisting of river gravels, submarine forests, drift sands, and large bodies of peaty vegetable matter, a set of deposits geologically so recent that in them we approach the confines of Archæology, and witness the two branches of science gradually merging into each other, until, in the soils and loams constituting the present surface of our country, geology resigns her functions, and is succeeded by her twin sister Archæology, a branch of science which brings down the history of man from the first traces of his advent upon earth to the present time, the memorials of whose presence in the form of rude stone implements first make their appearance in the rearranged river gravels and caves of our country, and in those of the continent of Europe.

If we slightly extend the limits so as to embrace Cumberland on the north and Yorkshire on the east, our range of geological observation will be considerably enlarged. Within the area thus indicated, we shall find the Skiddaw Slates of the first-named county, which by the researches of Messrs. Salter and Hicks in South Wales, and of Professor Harkness, Dr. Nicholson, Mr. Aveline, and Mr. Hughes in the Lake District, have within the last few years been correlated with the higher subdivision of the Arenig group of South Wales, a series of slaty, shaly rocks of great thickness, in which a rich profusion of

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Graptolites of various forms have recently been found, together with other organic remains, in a lesser degree. And, more recently still, Dr. Nicholson has brought to light a number of forms which he, with some little hesitation, refers to vegetable origin, a description of which, together with figures of four species, appeared in the November number of the *Geological Magazine* for the present year. Accepting this conclusion, and looking also to the teaching of modern research, it appears that animal and vegetable life existed in considerable abundance and variety on the land surface and in the ocean depths at this early period of the world's history. In the notice above referred to, as to the occurrence of vegetable remains in these Lower Silurian Rocks, the interest of this discovery is further enhanced by reason of its removing the first appearance of a terrestrial fauna upon the earth to a more subordinate horizon than that of any previously-recorded instance. The forms described by Dr. Nicholson were from the Upper Arenig Rocks, or Skiddaw Slates, whilst those discovered by Mr. Hicks were from the lower member of that formation: they may therefore be regarded as the most ancient, undoubted vegetable remains which have so far been brought to light.* Below these Upper Arenig rocks the researches of Messrs. Salter and Hicks at St. David's, South Wales, have brought to light a new set of beds estimated at 500 feet in thickness, in which the fauna is wholly distinct from, although approaching in character that belonging to the true Arenig age. This set of beds has now been classed as the lower division of the Arenig group. It will thus be seen that the Skiddaw Slates of the Lake District approach very closely to the base of the Silurian system, thus presenting to our view, within easy reach and in one of the most beautiful and interesting parts of our country, an immense vertical thickness of Lower Palæozoic rocks.

* Since writing the above my attention has been directed to an article which appeared in the *Geological Magazine*, vol. 6, p. 534, wherein conclusive testimony is adduced by Mr. Henry Hicks as to the occurrence of vegetable remains in these ancient Palæozoic Rocks. This discovery will doubtless be regarded all the more important as it not only establishes the fact of the existence of vegetable life on the surface of the globe at this early period of the world's history, but that the fauna of that era included forms of a comparatively high order of organisation, one of the specimens exhibiting undoubted evidence of "both articulations of the stem and an internal vascular structure," thus fully confirming the hypothesis put forth by Dr. Nicholson.

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An admirable treatise by Dr. Nicholson, in which all the most recent observations and facts bearing upon the difficult and perplexing question of the geology of the Lake District, has lately been published; and as this group of Palæozoic rocks has recently engaged much of the attention of geologists, I may be permitted to present in a condensed form some of the conclusions arrived at by him relating to this question.

Speaking of the geological structure of the Lake District, the author remarks, "That on looking at a geological map of Cumberland and Westmorland, it will be seen that the Lake District proper is composed of Silurian strata, which are flanked on every side by deposits of a later date belonging to the Old Red Sandstone, Carboniferous, and Permian formation."

He then goes on to say, that the Silurian nucleus has commonly been spoken of as constituting a dome-shaped mass, a theory which he thinks is "no longer tenable." In this view the author is strongly supported by Professor Ramsay, who, in his presidential address to the geological section at the British Association held in Nottingham in 1866, made use of the following observations: "With regard to the Cumbrian mountains, it has often been customary to speak of these as a great dome, forces from below having heaved up the strata towards a central point, from whence the main valleys radiate as great rents in the strata produced by that upheaval. But Cumberland shows nothing of a dome in the true geological sense; if it were so the strata ought to dip from the centre. But instead of that we find lower and upper Silurian strata from the equivalents of the Llandeilo flags to the Ludlow beds, forming, with subsidiary contortions, an ascending series all across Cumberland, from Cockermouth to Ambleside, with an average south-easterly dip." And concludes with these words, "there is indeed nothing cone-like in their arrangement." Dr. Nicholson then combats the theory of the older rocks of the Lake District having been raised along an axis of elevation running across the district in an E.N.E and W.S.W. direction, although this view is ably supported by Mr. Hopkins, and concludes that that supposition must also be abandoned, as it is now ascertained "that no such line of elevation exists," In presenting a general view of the geological features of the region, he states:—The district

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treated of in this essay comprises an area of about 40 miles in a N.N.W. and S.S.E. direction, and an average breadth of 25 to 30 miles : the chief portion of this area is occupied by members of the Silurian formation, the beds of which have a general strike of E.N.E. and W.S.W. The Silurian rocks of the Lake District are represented by members of both the lower and upper divisions of the formation, those of the former age being the oldest rocks found in the region : the middle division of the period (if it can be said to have a distinct existence), being apparently wanting. The base of the Lower Silurians is formed by the Skiddaw Slates, a vast series of purely sedimentary beds, attaining a thickness of about 7,000 feet, and representing the Lower Llandeilo or Arenig group. The Skiddaw Slates are conformably succeeded by the Green Slates and Porphyries, a group with a probable thickness of 7,000 to 10,000 feet, and composed almost entirely of Felspathic Ashes, and interbedded Porphyries in regular alternations, the whole of which, so far as yet known, are unfossiliferous, with the exception of a thin layer near the top. The entire group of the Green Slates may thus be considered, with great probability, as being partly of Upper Llandeilo, and partly of Lower Bala age. The Green Slates are in turn conformably surmounted by the Coniston Limestone, with its associated shales, the whole having an average thickness of about 300 feet, and being the undoubted equivalent of the Caradock, or Bala Limestone, of Wales. The Coniston Limestone is succeeded by a great group of slates, flags, and shales, which graduate into, and are surmounted conformably by the Coniston Grits, consisting of hard greenish-gray and gray grits with intercalated shaly and arenaceous beds, the whole of which the author believes constitute one single group, the thickness of which, as estimated by Mr. Aveline and Mr. Hughes, of the Geological Survey, is between 6,000 and 7,000 feet in the Sedberg and Howgill district. Professor Ramsay, Mr. Aveline, and Mr. Hughes, however, dissent from this conclusion, and contend that this group of rocks rests unconformably upon the subordinate Coniston Limestone, and that they consequently form the natural base of the Upper Silurians, of Westmorland. It is, nevertheless, admitted by Professor Ramsay that the evidence of unconformability in the district lying between Shap and the Dud-

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don is by no means conclusive, though there are some traces of it. When, however, the sheets of this district are published by the Survey, we shall doubtless find that satisfactory reasons will be adduced in support of this classification.* In opposition to these views Dr. Nicholson remarks:—"Professor Harkness and myself have, on the other hand, failed to detect any unconformability, or break of any kind, and the Coniston Flags and Grits are believed by us to constitute the top of the Lower Silurian series, having no exact equivalent in the typical Silurian district of Wales, but should be intercalated in point of time between the Bala Limestone and the Lower Llandovery. The Llandovery group appears to be entirely absent in the Lake District: this remark applies also to the Wenlock series, which does not appear to be there represented. The Coniston Flags and Grits are succeeded by a great thickness of Ludlow rocks, probably amounting to several thousand feet in thickness: these consist of variously-coloured Grits and Shales, are charged with characteristic fossils, and are terminated by beds supposed to be analogous to the Tilestones of Herefordshire." The author then sums up the foregoing remarks in the following terms:—"The noble Silurian system of Cumberland and Westmorland with the sub-divisions above enumerated is thus seen to attain an approximate thickness of from 25,000 to 30,000 feet, of which at least 20,000 feet must be assigned to the Lower Silurians."

It would occupy too much time to follow the author in his description of the position, thickness, and other details of the more recent formations which have subsequently been deposited unconformably upon the Silurian rocks, some of which are here found in very considerable force, particularly so the Permians, whose maximum thickness in the neighbourhood of Penrith is estimated to attain not less than 8,000 feet. Nor can we stay to examine the speculations of Dr. Nicholson as to the former connection of the Isle of Man with the Cumbrian district, the probable time of its separation therefrom, nor the correlation of the rock masses of the two localities.

I, however, think it inadvisable to dismiss this contribution to Silurian geology without first directing attention to the author's

* The correlation of the Welsh and Cumbrian Silurian strata, as understood by the Geological Survey, will be found in the published index of colours and the survey.

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observations on the numerous faults and dislocations which traverse the two counties, and to whose effects he thinks the region to a large extent owes its present configuration. The remarks on this subject will probably be received with additional interest in consequence of the attention which has recently been directed to this branch of physical science, with the view of determining the laws and forces which have operated most powerfully in moulding the earth's form, and in producing the surface contour we now see around us. In treating upon this subject, the author remarks, "It is to Professor Harkness that we owe the important discovery that the great faults of Cumberland and Westmorland can all be classed in one or other of two great systems, which cut each other at right angles. The faults belonging to one of these systems have a prevailing E.N.E. and W.S.W. direction, and coincide, therefore, with the strike of the Silurian rocks, and with the axis of their numerous flexures. Like those of the newer system, these faults occur in the north of England, wherever the Palæozoic rocks present themselves, but they are incomparably more ancient, since they affect the Silurian strata only, and the irregularities produced by them were entirely removed by denudation, before the deposition of the upper old red sandstone, The faults of the second system have generally a direction perpendicular to the former, or from N.N.W to S.S.E., thus being at right angles to the strike of the Silurian rocks, and corresponding very nearly with their normal dip. Whilst the date of the older system can be definitely assigned to the interval between the Upper Ludlows and the deposition of the conglomerates of the upper old red, that of the newer group is not so certain. That all of them were produced after the Carboniferous epoch is certain; that most of them were posterior to the deposition of the Permian strata is equally certain; and it is not impossible that some were produced even in the close of the secondary period." To the former of these systems belongs that series best known to geologists as the Penine fault. This enormous dislocation, which takes its rise in Dumfriesshire, in the north, and extends to Kirby Lonsdale, in the south, has produced a maximum displacement of strata in the Cross Fell district, amounting to from 6,000 to 7,000 feet, the downthrow being on the westerly side of the fault. The author then goes on to show

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that these fractures constitute lines of weakness, along which the various denuding agencies have acted with the greatest efficiency; amongst the most powerful of which he includes glaciers, rivers, and pluvial action; at the same time not overlooking the effect of the sea on a land slowly rising from the deep. To the action of these various forces operating over a vast lapse of time, he ascribes the present surface contour of the country, and the existence of the numerous lake basins, which he considers are depressions scooped out by the same means.

In the recent edition of Siluria, the venerable and distinguished author, Sir R. I. Murchison, in referring to the physical characteristics of the Lake country, bears testimony to the valuable services rendered in this field of geology by Professor Harkness and Dr. Nicholson, and endorses the conclusions arrived at by them as to the age of the most ancient deposits found in this district, which he now recognises as of undoubted Lower Silurian age, although previously classified by Professor Sedgwick, and generally acknowledged as belonging to a formation much anterior in point of time. Sir R. I. Murchison, however, still adheres to the classification originally adopted by Professor Sedgwick as regards the Upper Silurian formation, which embraces the Ireleth Slates as one of its subdivisions, and which he considers equivalents of the Wenlock formation, although, as observed by Dr. Nicholson, "the entire group has been given up by Professor Sedgwick himself, and there can be no question but that the phenomena observed are due to a repetition of the divisions of the Coniston series by means of transverse E.N.E and W.S.W. faults."

Although some of the conclusions arrived at by Dr. Nicholson, in the treatise from which I have made such copious extracts, require further elucidation and confirmation, I consider the work in question as a valuable contribution to the geology of the Lake district, and one which may be read with advantage by all those interested in this branch of geologic study.

Turning now to the east, in the adjoining county of Yorkshire, we find the several members of the Jurassic and the upper beds of the Cretaceous systems fully developed, the whole of which are so favourably situated as to afford the best possible opportunities for a complete

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examination, not only of the physical constitution of the various beds, but also of their characteristic fossil contents, which are found on the eastern shore of this county in such abundance and variety. We have here, then, within the comparatively limited area embraced in the three northern counties, Lancashire, Yorkshire, and Cumberland, a series of formations presented to our view, commencing with the Skiddaw Slates and continuing without serious interruption through the intervening formations to the higher part of the Cretaceous formation. In this immense thickness of rocks, so varied in character, abundant opportunities are presented for investigation, suited to each individual taste or fancy.

Within the limits thus defined the Carboniferous system is fully developed, each member having its representative. Within this area we also find two of the most valuable and productive coal-fields in England, viz., those of South Lancashire and Yorkshire, which yield an annual produce of about twenty-two and a half millions of tons of coal, to which if we add one and a half million of tons for the Cumberland mines, will give a total of twenty-four millions, or twenty-three per cent of the gross produce of the United Kingdom. The extent to which the strata have been penetrated in the Carboniferous formation, in searching for coal and in carrying on the operations of mining, has afforded the most ample opportunities for investigating their character, composition, and the relation of the several parts; and, by the same means, the interesting organic remains so profusely distributed through large masses of them have been placed within reach of the palæontologist, by whose investigations most important results have already been attained. Much, however, yet remains to be done, particularly in the department of fossil botany; for although Brogniart, Hooker, Binney, Carruthers, and others have from time to time presented to the scientific world most valuable communications on this important subject, it must be admitted that this department of science is by no means in so advanced and satisfactory a state as could be desired; for, in addition to the interest pertaining to the prosecution of this branch of study for its own sake, it has an important bearing upon the character and composition of coal; and the conditions under which that most valuable mineral was deposited. It is therefore to be hoped that each one will be on the alert, that no opportunity may be

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allowed to escape whereby our knowledge on this subject may be promoted.

Reference has already been made to the district of Furness, a detached portion of our county, forming a kind of peninsula on its north-western border, as possessing within its limited area representatives of most of the Lower Palæozoic rocks, and presenting geologic features of a varied and highly-instructive character. Its chief interest, however, centres in the rich deposits of Hæmatite iron ore, found there in such vast abundance, and under such extraordinary circumstances. This subject has been ably treated by Mr. Binney, the result of whose researches will be found in the published transactions of the Manchester Literary and Philosophical Society. A paper was also read to this society on the Iron ores of Furness, some time ago by our late president, Mr. Greenwell. Much other literature also exists bearing on the same question. It will not, therefore, be necessary that I should, on the present occasion, do more than call attention to the subject in general terms, and point out the important influence its presence has exerted in the district under review.

These deposits of iron ore not only possess great scientific interest, but are also highly important in an economic point of view. The development of the mineral resources of Furness has of late years proceeded with wonderful rapidity. The annual produce, which in 1854 stood at 336,000 tons, reached last year a total of about 800,000 tons, showing an increase of 138 per cent in 15 years. This enormous excess in the productiveness of the district has rendered itself manifest in all its commercial relations and undertakings. It has called into existence one of the most successful systems of railway communication in our country; has transformed in a few years a small obscure fishing village into an important seaport town, with commodious docks and large stacks of warehouses; has led to large and successful investments being made in mining operations, and in the erection of extensive smelting works for converting the ore into pig iron; and has drawn together a large body of miners and other labourers where only a sparse agricultural population could have been maintained without these stimulating influences.

The origin of this immense mass of ore has long been a subject of difficulty with scientific men: much ingenious speculation has been

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indulged in by some of our leading geologists, but as yet no satisfactory conclusion has been arrived at. Mr. Bolton, of Ulverston, a shrewd, active, and intelligent observer, who, during a period of upwards of sixty years, has accumulated a mass of facts bearing upon that and kindred subjects relating to this locality, and who has recently given to the world the benefit of his observations, in an interesting volume* refers to this question in the following terms: "We may therefore well say that the formation of our Hæmatite ore is veiled in obscurity, and we have not attempted to unravel this knotty point, our remarks hitherto having reference only to the relative age of the two deposits†, the graver difficulty we leave to abler hands." With regard to the age of this mineral deposit the evidence is much more satisfactory. In a paper read before the Literary and Philosophical Society of Manchester, in the year 1867, "On the age of the Hæmatite Iron Deposits of Furness," Mr. Binney showed, from specimens he there exhibited of fossil vegetable remains, of undoubted carboniferous type, found imbedded in the iron ores of Furness and at Water Blain, in Cumberland, that the true age of the Hæmatite ore must correspond with that of the Carboniferous epoch. More recently, the discovery of numerous fossil shells in the iron ores of Lindal Moor, and other places, all of which are of undoubted Carboniferous Limestone species (a large suite of which I have very recently had an opportunity of examining, and a small selection from which is now in my possession, which I shall be glad to exhibit to the Society on a future occasion) most satisfactorily corroberates the conclusions arrived at by Mr. Binney in the paper above referred to.

The Millstone Grit formation, which in some parts of the country has no representative, and in others exists only as a thin and unimportant bed of coarse, soft rock, presents in the north-eastern part of our county a marked and prominent feature, where it, together with the other sedimentary rocks associated therewith, are, according to the investigations of Mr. Hull, developed to an extent not found in any other part of England, and from which they diminish in thickness in every direction, but notably so as we proceed to the south-

* Geological fragments collected principally from rambles among the rocks of Furness and Cartmel, by John Bolton.

† The Carboniferous Limestone and Hæmatite Iron Ore.

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east. The series of grits and shales of the northern counties has generally been considered as destitute of all trace of animal life: more recent discoveries have, however, revealed to us the fact that during the period of their deposition the co-existing fauna was by no means limited either in specific forms or individual numbers; true it is that the coarse sandstones of this series have not as yet yielded any undoubted examples of the animal life of the period. On the other hand, the interbedded black carbonaceous shales are gradually becoming known to geologists as the receptacles of a varied fauna. From a layer of calcareous nodules enclosed in a fossiliferous bed of higher millstone-grit shales, at Rough Lee, in Pendle, I have succeeded in collecting five or six species of Goniatites, two or three of Orthoceratites, two of Posidonomya, two of Aviculo-pecten, together with other forms; in addition to which the late Mr. Whitaker, of Burnley, obtained two small Gastropods and a fish tooth of the genus Cladodus; more recently, Mr. Tiddeman and Mr. Eccles have discovered abundance of encrinital remains in beds of shale of this age; the former on the banks of the Ribble, near Ribchester; and the latter near Roach Bridge, on the river Darwen; and near the same place, some years ago, Mr. Binney mentions meeting with Goniatites in a bed of black shale, which is now recognised as belonging to this formation. The grits superimposed upon the mountain limestone of Bristol and Oswestry, have, for a number of years past, been known to contain fossils of several species in considerable abundance. These rocks have, however, a widely different character to our northern grits; and it is a question at least open to doubt, whether they can permanently be retained as members of the milstone-grit formation, whether viewed in relation to their lithological character, stratigraphical position, or their fossil contents, although generally regarded as belonging to that formation, both by the geological survey and other geologists.

The millstone-grits of Lancashire and Yorkshire are also generally regarded as exhibiting an almost total absence of calcareous matter in their structure. This view must, however, be modified to some extent, as I have recently succeeded in tracing a bed of impure grey limestone, or highly calcareous grit, over an area of several square miles in the neighbourhood of Hebden Bridge. This bed is of very considerable

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dimensions, reaching in one exposure a vertical thickness of at least fifty feet. It occurs near the base of the millstone-grit, and is only separated from the Yoredale shales by a bed of massive, coarse, grit rock. From the highly calcareous character of this rock, I entertained strong hopes that organic remains would be detected therein, though I have so far been disappointed in that hope. A more minute and searching examination may reveal their presence to some more fortunate explorer.

I must now conclude this address, which I fear has already been unduly prolonged, by thanking you for the kind reception which has been accorded me this day, and by a reiteration of the hope that the session now inaugurated may prove in every way a successful and satisfactory one; that the Society's sphere of usefulness may be enlarged; and that each individual member will feel himself called upon to use every exertion in his power to secure the accomplishment of this desirable object.

MANCHESTER GEOLOGICAL SOCIETY.

A Monthly Meeting of this Society was held in the Museum, Peter Street, on Tuesday, December 21st, 1869—J. Aitken, Esq., F.G.S., President, in the Chair.

Mr. Charlton (Hon. Sec.) announced that since last meeting the following publications had been received:—

"Proceedings of the South Wales Institute of Engineers;" several numbers of "Nature;" and a work by Mr. Hull, entitled "Triassic and Permian Rocks of the Midland Counties."

The Chairman: Since the last meeting Mr. Livsey, one of the honorary secretaries, has resigned his position, and in his place the Council have appointed Mr. W. Boyd Dawkins, who will now act as Secretary.

The following papers were read:—

On Two Dykes recently found in North Lancashire. By James Eccles, Esq., F.G.S.

The three specimens to which I call the attention of the members of the Society, I have obtained from two dykes, one near Grindleton,

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the other near Caton, in North Lancashire, of the existence of which I had been informed by Mr. R. H. Tiddeman, F.G.S., of the Geological Survey.

The first-mentioned dyke is seen in a brook about a mile north of Grindleton, near Clitheroe, on the west side of and within a few paces from the road.

The shales in contact are considerably altered and hardened, and a slight alteration can be detected to a distance of 5 to 6 feet.

The thickness of the dyke is 10 feet; its direction N.W. and S.E., and it has a slight hade to the N.E. Its composition appears to be that of a fine-grained greenstone.

Although I have searched carefully in this district, especially on the prolongation of the line of strike of the dyke, I have been unable to find any further indication of its presence.

The second dyke alluded to is found in a stream called Tarn Brook, two miles E.S.E. of Caton village, and again in another stream a quarter of a mile further to the south-east.

In the first case the direction is N.N.W., the hade north-easterly, and the thickness of the dyke 4 feet 6 inches.

In the second case the strike 30° E. of S., and the thickness 4 feet 10 inches.

The appearance of this dyke differs from that at Grindleton. It is light in colour, very vesicular, and effervesces freely with acid.

It is a remarkable coincidence, that if a straight line be drawn on the one inch ordnance map along the continuation of the line of strike of the Grindleton Dyke to the N.W., this line will either join in with, or pass very close to, the dyke near Caton, a distance of 16 miles. This line also passes through the lead mines of Whitendale, about half-way between Grindleton and Caton; and although no occurrence of a dyke is established in this district, yet on one occasion, before the discovery of the dyke at Grindleton, Mr. Tiddeman, in my presence, picked up a fragment of what appeared to be trap out of one of the refuse heaps of the mines. This was afterwards submitted to Mr. Bristow, and was declared by him to be basalt.

I had a suspicion, after examining the Grindleton Dyke, that there might be a connexion between it and that found near Caton, but the evidence is too slight to form any reliable conclusion.

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I believe the two dykes I have described are the only instances known in Lancashire south of Morecambe Bay, and as such may be interesting to this Society.

Mr. Binney stated that the only dyke he knew of in North Lancashire was in the neighbourhood of Furness, on the other side of Morecambe Bay.

Mr. Dickinson asked whether the dyke traversed the coal measures.

Mr. Eccles: No; it was confined to the shales underneath the grit.

The Chairman: The dyke mentioned by Mr. Binney, in the southern part of Furness, is quite of a different character to this; it has much more iron than this, I presume, from its appearance.

Mr. Dickinson: It would be well if Mr. Eccles would say exactly where these dykes are to be seen, because Caton and the places and townships mentioned, are a wide district to scour over.

Mr. Eccles: The one at Grindleton is about a mile above the village of that name, on the road to Slaideburn, on the west side of and within a few paces from the road. The one at Caton is on Caton Moor, two miles south-east of Caton village.

The President exhibited a fine cast of Homalonotus, which had been presented to the Society by Mr. E. Hollier, of Dudley; and read the following paper:—

On a Specimen of the Homalonotus Delphinocephalus, found at Dudley.

BY Mr. EDWARD HOLLIER.

The cast which I have had the pleasure of presenting to the Manchester Geological Society, through its president, Mr. Aitken, is that of the beautiful and celebrated fossil formerly belonging to the late T. H. Bracewell, Esq., of Dudley, and now deposited in the Museum of Practical Geology, Jermyn Street, London. It was for some time one of the chief characteristic species of the Dudley Geological Society's collection, and was especially noticed by Sir R. I. Murchison, Bart., in his opening address at the establishment of the

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first society in that town, in 1841. The fossil was found some thirty or forty years ago, in a particular stratum of the limestone on Dudley Castle Hill, and for a very long period was the only perfect specimen known in that district. In giving a short sketch of its history, it may not be out of place to remark that the Castle Hill consists of beds of Wenlock Shale, with two bands of limestone, the upper or thinner of which is about eight or ten yards, and the lower or thicker, from ten to thirteen in thickness. The Castle grounds, including a small semi-detached part, called Kettle Hill, at its northernmost part, as will be seen by a glance at the Geological Society's Survey Map, may not inaptly be said to represent a pear in its general outline, having its broader part to the southern or town end of its enclosure.

Castle Hill would appear at one time to have been surrounded by the two bands or beds of limestone before referred to, separated by about thirty yards of shale, and both cropping out on its summit, forming the crown of the range. The thinner or outer bed, in consequence of lying very near to the surface, has doubtless from a very early period been used in the construction of buildings, for converting into lime, and other economical purposes. The noble old ruins which still crown the summit of the hill have been built with stone obtained from it. Each bed or layer has been now almost entirely removed by open work, or mining operations, carried on by means of extensive galleries, one below the other, to some considerable depth. The Castle Hill at one time afforded almost the only spot for limestone-quarrying in the district, and has been a source of great wealth to its noble owner. The stone, when quarried, was removed by canals penetrating the hill in different directions, branches of which, not long ago, extended about two-and-a-half miles under the town from Tipton, on the north-eastern side, to Park Head, on the south-western, and formed one of the principal water routes for the traffic of the district in those directions. The notable Silurian caverns, which measure about 800 yards long, and 50 feet high, still remain as remarkable monuments of the extensive operations formerly carried on here, and exhibit in a striking manner the inclination, structure, and mode of working the beds. It was in one of the smaller excavations on the eastern side of the hill that the splendid specimen of

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the Homalonotus Delphinocephalus, the subject of this sketch was found: several fragments, and one or two very imperfect specimens, were all else which up to that period had been obtained. For a considerable period no additional remains were found. A few years ago, however, further research was instituted in the locality of the former discovery, which resulted in bringing to light some good examples of this rare crustacean. The caverns in question are now closed, and it is very seldom that even fragments turn up. Salter describes the Homalonotus delphinocephalus as abundant at Dudley, but this is by no means the case; or, perhaps, I might rather say that the particular stratum in which they may be abundant, is but very seldom exposed, and therefore they are rarely found, and extreme prices are always obtained for good specimens. Although the delphinocephalus has a wide range, passing through the lower, middle, and upper beds, still, when fortunately obtained in a perfect form, I have not seen any which can compare for the beauty of their preservation with those obtained from these beds. They would, nevertheless, appear to be principally confined to a layer about three feet in thickness, which overlies the thicker limestone; and some places afford indications of their having congregated there in considerable numbers. It may, however, be remarked that fossil remains are not nearly so numerous in the lower measures as in the shale immediately above; but when they do occur they are usually in a very fine state of preservation.

It is to be observed also that, whether in regard to the Homalonotus, the Calymene, or some other species of Crustacea, or whether as to particular classes of Crinoidea, that each is to be found in the greatest abundance and in most perfect condition in certain and particular strata, which are well known and recognised by the workmen and collectors; whether at the time of the deposition of the several beds the particular form of crustacean, crinoidean, or coralline life, the remains of which are seen to be most abundant in them, largely prevailed and, consequently, more are preserved in a fossil form, or there might have existed special reasons for a greater development of each particular phase of the life we observe to have existed at that remote period I pretend not to say, but it is a fact well known and easy to be observed. Although there are specimens of the young

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of the Homalonotus of a comparatively minute size, the delphinocephalus is the largest of the different species of Crustacea found in the Silurian strata of this neighbourhood. The specimen from which the cast was taken measures about six inches long by three broad at the base of the head. There are also in the collection of E. J. Hollier, jun., others from six to six and a half inches long, by from three to four and a quarter broad. We may therefore fairly presume that these examples represent the animals as fully developed and of their largest size.

The H. delphinocephalus is the only species found at Dudley; and I have never heard of any specimen of either the Knightii of the upper, or of those restricted to the lower measures, being discovered in this locality. For the anatomical and distinctive characters of the species, I would refer you to Salter's Monograph, and other palæontological writings, as I would hardly presume to dilate upon them. At some future time I hope I may be able to present to your museum a real specimen of this fossil instead of a cast.

THE DENBIGHSHIRE CAVES.

BY W. BOYD DAWKINS, M.A., F.R.S.,

Hon. Secretary to the Manchester Geological Society.

The mountain limestone in Denbighshire consists of a series of reefs, that rest either on a thin representative of the old red sandstone, or immediately on the upper Silurian rocks, which occupy by far the largest area in the county. It forms the precipitous promontory of the Great Orme's Head, and thence sweeps, with but slight interruption, along the coast as far as Abergele, and thence passes inland to make the picturesque series of ridges that add so much to the beauty of the vale of Clwyd as far as Denbigh and Ruthin. It suddenly disappears on passing out of the vale towards Bryn Eglwys, to the north of which it forms a broad belt, passing through the heart of Flintshire, and plunging under the millstone grit of that coal-field,

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past Mold, Holywell, and Whitford. To the north-east it is brought up by a fault, and thence passes due south in a continuous narrow band as far as the valley of the Vyrnwy, on the border of Montgomeryshire. Throughout this area caves are more or less abundant, and fall naturally into three great divisions: those which are either empty or being now gradually filled by atmospheric and aqueous agencies with red silt, sand, and gravel; those which have been thus filled before history began in our island; and lastly, those which were filled during the postglacial or quaternary epoch. The first, or the recent, are now the home of the badger, the fox, and the rabbit, and are frequently the graves of sheep, horses, and oxen. The second, or the pre-historic, have been the homes and the burial-places of ancient races of men before the Roman invader set foot on our shores; they also afforded shelter to the brown bear and the wolf, as well as to the wild animals that are still indigenous. The third, the post-glacial or quaternary caves, also have been filled with deposits at a time indefinitely removed from the present, and during which the conditions of life differed entirely from those of to-day. Grizzly bears, cave bears, hyænas, and lions preyed upon the herds of bison, horses, and mammoths that then lived in our country; and the reindeer existed in countless numbers, proving by its very presence the severity of the winters at the time. The discussion of this latter class of caves I hope shortly to bring before you. In this essay I propose to give a short account of those of the second or pre-historic class, which I have had the good fortune to examine in the summer and autumn of 1869, at Perthi Chwareu, about ten miles to the east of Corwen, and at Cefn, near St. Asaph.

The first hint of the existence of a bone cave at Perthi Chwareu was afforded me by a box of bones sent by Mr. Charles Darwin, and I followed it up by availing myself of the kind offer of workmen and assistance made by the owner of the property on which the cave is situated, Mrs. Lloyd, of Rhagatt. The mountain limestone there consists of thick masses of hard rock, separated by soft beds of shale, and contains enormous quantities of producti, crinoids, and corals. The strata dip to the south at an angle of nearly one in twenty-five degrees, and form two parallel ridges with their steep faces to the north, and separated from each other by

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a narrow valley passing east and west along the strike. The remains sent by Mr. Darwin were obtained from a space between two strata near the top of the northern ridge, whence the intervening softer material had been carried away by water. Its maximum height was six inches and its width twenty feet or more, and it extended parallel to the bedding of the rock. The bones had evidently been washed in by the rain; nearly all of them were broken, and belonged to young animals. Those of the Celtic short-horns (*Bos longifrons*), and of the sheep or goat, and of the young pig, were very abundant. Those of the roe deer, red deer, hare, and horse, were comparatively rare. There can be no manner of doubt that these had been used for food by man. The remains of the domestic dog were also abundant, and the percentage of young puppies would imply also that it had been used for food. Possibly also the hare may have been eaten, and the fox, badger, and water-rat, but the remains of the former animal were scarce and belonged to adults. Some of the bones had been gnawed by dogs. The only reasonable cause that can be assigned for this accumulation is, that the locality was inhabited by men of pastoral habits, but yet, to a certain extent, dependent on the chase, and that the relics of their food was thrown out to form a refuse heap, like those in Denmark. The refuse heap has now altogether disappeared from the surface of the ground by the action of the rain and other atmospheric causes, while those portions of it which chanced to have been washed into the narrow interspace between the strata, have been preserved.

There was nothing in the deposit that fixes the date of its accumulation: it may have been of the stone, bronze, or iron age; but from the presence of the sheep, or goat, short-horned ox, and dog, it certainly does not date so far back as the epoch of the reindeer, mammoth, rhinoceros, and cave-hyæna. The absence of pottery would imply that it was of pre-Roman age; for, in the refuse heaps accumulated during the Roman occupation of Britain, I have invariably met with quantities of pottery. In Saxon, Norman, and mediæval kitchen-heaps, potsherds are by no means rare. The presence of the Celtic short-horns throws no light upon the antiquity, because, for centuries after it had ceased to be the domestic breed in England, it still remained in Wales, and still lives in the small black Welsh cattle.

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At a little distance from the accumulation of bones, and at a lower level than the rock there is a cave full of red silt, in which we dug for a short distance without any result.

While the work on this ridge was in progress, I walked across the valley to the southern ridge, and selected a small hollow in the precipitous side that formed a kind of rock shelter, and seemed to be a likely place for the discovery of remains of man or of wild animals. It was about fifteen feet above the level of the valley. On setting the men to work, in a few minutes we began to discover remains of horse, goat, hare, rabbit, badger, large birds, wolves, wild cats, foxes, and Celtic short-horns, roe and red-deer. Mixed with these, as we proceeded, we began to find human bones, between and underneath large masses of rock, that were completely covered up with red silt and sand. As these were cleared away, we gradually realised that we were on the threshold of an ossiferous cave. In the small space we then excavated, human remains belonging to no less than five individuals were discovered. At this interesting point in the exploration I was compelled to go away; but the work was carried on by Mrs. Lloyd, under the careful supervision of Mr. Reid. The rock shelter narrowed into a "tunnel-cave" that penetrated the rock in a line parallel to the bedding, and roughly speaking at right angles to the valley, having a width varying from 3 feet 4 inches to 5 feet 6 inches, and a height from 3 feet 4 inches to 4 feet 6 inches. It has been explored for a distance of about 28 feet.

The entrance was completely blocked up with red earth and loose stones. Inside the cave was filled with silt and sand to within about a foot of the roof. In this the remains were found, chiefly on or near the top; but in some cases they were deep down in the deposit. One human skull, for instance, was found six inches only above the floor of rock. The human bones were mixed pell-mell with those of the animals which have been enumerated. One human femur was in a perpendicular position. The account of the continuation of the digging I will give almost in the words of Mrs. Lloyd. On the second day, after an hour's work, a human skull was found near the roof of the cave, resting on a femur. There were also found in the eleven feet explored on that day, a large number of human bones, including nine femora. The third and fourth days were

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devoted to clearing out the cave to the bottom up to this point, and to excavating about four feet further in—namely, fifteen from the entrance. During this work, two teeth of the horse were found on the floor, near the entrance, and nine more about ten feet within the cave; a boar's tusk of remarkable size, and close by it a mussel and cockle-shell along with a quantity of human and other bones, including five skulls, more or less perfect, and many fragments. All the skulls were found from ten to about fifteen feet from the entrance. During the fifth and six days the work was superintended by Mr. Reid, who entirely cleared the cave for about thirteen feet further; while the first eight feet were being excavated a small quantity of human bones were found intermixed with those of other animals, including a perfect skull of a marten cat, and an incisor of a wild boar. The only implement found in the cave, a broken flint flake, occurred here, and a nearly perfect human skull, lying face downwards, with a pelvis adhering to one side. The last five feet only furnished two bones.

Small bits of charcoal occurred throughout the cave, and a great many rounded pebbles from the boulder clay of the neighbourhood. Within the first ten feet there were bits of modern glazed pottery and small pieces of coal, and near the end of the excavation a small scrap of iron was found, which seems to me to be a mere splinter broken from one of the tools of the workmen. The coal and the modern pottery have most probably been conveyed into the cave either by the wash of the rain or possibly by the burrowing of the rabbits which abound in fissures in the rocks immediately above the cave. The fact that the splinter of iron is scarcely oxidised implies that it had not been in the cave very long.

The human remains belong for the most part to very young or adolescent individuals, from the small infant to youths of twenty-one. Some, however, belonged to men in the prime of life. All the teeth that had been used were ground perfectly flat. The skulls belong to that type which Professor Huxley terms the river-bed skull. The tibiæ present one remarkable peculiarity, now for the first time recognised in any British leg bone. They are very much compressed in a plane parallel to the median line, and indicate the platycnemic character, or the bandy-leggedness of the people to whom they

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belonged. Precisely the same character has been recognised in remains from the caves of France, and is presented also by the only fragment of bone which has been obtained by Mr. Foote from the laterite of India.

The remains of the animals in the cave belong to the same species as those which have been before mentioned from the *débris* of the kitchen heap, and are precisely in the same condition. From their close intermixture with the human remains they must have been deposited with them at the same time.

But how can we account for the presence of the human remains in the cave. Unlike those of the other animals, they are for the most part perfect. They exhibit no marks of scraping and cutting, and, therefore, cannot be viewed as the relics of the feasts of cannibals. The only satisfactory explanation is, that the cave was used as a burial-place. That the dead were not interred at one time is conclusively proved by the fact that the number of individuals was far too large to be accommodated in so small a space. They must therefore have been buried at different times. Moreover, they were certainly not buried at full length. Most probably, from the juxtaposition of one of the skulls to the pelvis, and the vertical position of a femur, they were buried in a sitting posture, as in some of the stone chambered tombs of Denbighshire. The confused heaps in which the human bones were found makes this inference almost certain.

The flake of flint is an uncertain guide to the antiquity of the burial-place, for the use of flint for solemn purposes lingered on long after that material had been driven out of use in every-day life by bronze andiron. In Egypt, for instance, the first incision in a corpse to be embalmed was made with a sharp flint, although both bronze and iron were in use at the time. In the foundation of the king's palace at Khorsabad flint flakes were deposited, probably for some superstitious reason. In a Romano-British grave at Hardham, in Sussex, I discovered a flint flake. Yet in all these cases a great mistake would be made were the Egyptians, Assyrians, and Roman provincials in Britain relegated to the stone age. Flint flakes, moreover, were employed for cutting purposes long after the introduction of bronze, and very possibly after the introduction of iron. The occurrence, therefore, of the flint flake in the cave of Perthi Chwareu does not of itself imply

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that the people who used it are of the stone age. According to our present knowledge we can only say that the possessors of the river-bed skulls lived in Britain at a very remote period, far removed out of our ken. It is very probable that the folk who ate the animals found in the *débris* of the refuse-heap clearly were the same as those who used the cave as a burial-place. The identity of animal remains in both is strongly in favour of such a view.

The cave of Perthi Chwareu is by no means unique among the caves of Denbighshire for the discovery of human remains. In the collection of Mrs. Williams Wynn, made from the caves at Cefn, there is a human skull of the same type as that of Perthi Chwareu. It was found along with the bones of sheep or goat, pig, fox, badger, cut antlers of red deer, and three flint flakes near one of the entrances of the cave in which the extinct post-glacial animals occurred in the valley of the Elwy. There can be no doubt that these interments are of the same class, and were made by the same race of people.

The peculiar value of the evidence afforded by these pre-historic caves of Denbighshire is derived from the proof that they afford that the possessors of skulls of the river-bed type were platycnemic. It requires but little imagination to picture them leading a pastoral life, varied every now and then by the chase in Denbighshire, and leaving behind the relics of their feasts to mark their dwelling-places, and burying their dead in caves. Platycnemic men, moreover, have been found in South France and India, while the river-bed type of skull occurs both in Scandinavia and Spain; and thus there is a high probability that these ancient dwellers in North Wales belonged to a race that spread throughout Northern and Western Europe, and it may be even into India.

The Chairman: I think it must be admitted that the skulls vary very much in form and size, and it perhaps would scarcely be safe to conclude that because you find skulls at two particular places, they belonged to one race distinct from other people living at other times.

Mr. Dawkins: I do not mean to say that you can always tell a man's race or nation by his skull. When you find over a certain area a certain class of skulls associated with certain remains the association is fair evidence, and about the only evidence you can get.

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If I found, say, in that part of Wales, in two caves, twenty skulls all of the same type, associated with the same animal remains, and altogether indicating similar habits and modes of life, I should take it for granted that the skulls belonged to the same people. You will find that these were the skulls of men who used their teeth very much; that they had much better teeth than most of us are blessed with, but that the teeth were all ground down flat.

The Chairman: Is it not a fact that skulls have varied very much in different periods of the world's history? The question is whether this was accidental, or whether it is established on scientific data that skulls at different periods did assume different forms.

Mr. Dawkins: If you were to examine three hundred or four hundred skulls in a charnel-house, you would find the long heads and the short heads together. Very likely some of the ancient short-headed men are still represented lineally. In the old days you had now and then, of course, a long skull and a short skull together, but you will not find it to be the case half so often as you might expect.

The Chairman: Did the cave which you explored follow the stratification of the rock?

Mr. Dawkins: It cut across it a little.

Mr. Chatwood: Was there much silt, or gravel, or clay?

Mr. Dawkins: There was the common red cave earth or loam.

Mr. Dickinson: Were there any roads or old buildings near this place?

Mr. Dawkins: There is a farm-house about a hundred yards off.

Mr. Dickinson: In the times of the Ancient Britons they might have look-outs at the top of these hills, and the people whose remains these are may have been killed by soldiers and thrown into these caves to be got rid of.

Mr. Dawkins: It is difficult to admit that supposition, because the cave was so small they could not have introduced so many bodies all at once.

The Chairman suggested that Mr. Dawkins should be requested to embody his communication in a written form, in order that it might be printed in the transactions of the Society; and a resolution to that effect was passed on the motion of Mr. Greenwell, seconded by Mr. Hardwick.

The proceedings terminated with a vote of thanks to the Chairman.

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TRANSACTIONS

OF THE

MANCHESTER GEOLOGICAL SOCIETY.

No. 2.] VOL. IX. [Session 1869-70.

A Meeting of the Society was held on Tuesday, January 25th, at the Manchester Museum, J. Aitken, Esq., the President, being in the Chair.

The Chairman, in opening the proceedings, said: There lies before you, gentlemen, the cast of the impression of a fossil, which has been discovered in the lower Lancashire flag-rock. Its form is one which I have never seen before, and which I believe to be new to science. In all probability it is a fish; but, so far as has yet been determined, it would, perhaps, be unwise to give a positive opinion. That it is an organic substance, there can, I think, be no doubt. There are evidently a number of vertebræ and side spines, together with head prints, which to my mind show it to be the form of some animal remains. I am sending the cast to London, to have it examined by some competent palæontologists, and, perhaps, we may hear more about it on some future occasion.

Mr. W. B. Dawkins: I have cursorily examined the cast, and so far as one can judge of anything which has been preserved in that peculiar kind of matrix, it seems to me to indicate a chain of vertebræ and other *debris* of some kind of reptile. If these impressions are really those of vertebræ, I have little doubt that this is one of those remarkable carboniferous reptiles of which at the present time we know very little. It is a very interesting remain, and would, I think, require a good deal of examination in order to determine clearly its real character.

Mr. Ormerod: Is the original in existence?

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The Chairman: I have the slab, and that cast was taken from it. So far as I know, no animal remains have previously been found in the flag-rock—none of the fauna of the period, though vegetable remains are sometimes formed.

Mr. Darbishire: Does this flag-rock lie upon what is called the rough rock coal?

The Chairman: Yes.

Mr. Ormerod: I observe some small depressions like finger-end prints,—are they commonly seen?

The Chairman: These are probably caused by rain drops.

The Chairmen then called upon Mr. John Warburton to read a promised paper on "Some of the Causes of the Different Modes of Working and Ventilating Coal Mines."

Some of the Causes of the Different Modes of Working and Ventilating Coal Mines.

BY MR. J. WARBURTON.

That there is a difference in working coal, no one who has been out of the district in which he was born, or paid even a little attention to what is going on, will dispute. Regarding the mode or operation of extracting coal in earlier years, little or nothing is said or put on record. We are not, however, up to this time in ignorance of how coal was got out a century or two back. A good idea may be gleaned from collieries that have been worked time out of mind, or, in other words, from coal-fields that have been known and worked the longest. In most of those districts, near the out-crop of each seam, it may be seen, or the information gathered from elderly miners, how the coal was got. Not a few of these former-wrought collieries have been re-opened, to work again the seams that have been previously abandoned. We frequently find them with not more than half the coal worked out, this portion being got out in very narrow strips. I have seen them from two to five yards wide. I should conceive from those I have seen that the idea was to keep the roof up in its entirety, but if it fell they would leave that face and open another.

Another instance, of peculiar interest, I have noticed in these old

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workings, that the places were all driven on the face or board of the coal, ignoring altogether the direction of inclination of the bed.

It is interesting to trace results of any kind back to their cause; doubly interesting is it in such matters as the production of coal, for we have not only the satisfaction of arriving at the cause, but feel a freedom in drawing inferences from it, as it is the *results* that affect us commercially.

We will dispose of these by tracing their cause, and then come down to more modern coal-mining.

As regards the first of these, in early mining, it is easy to understand that all parties would consider that a great amount of danger and risk attended the extraction of coal from under a portion of the earth's crust. This would arise from a fear of the earth falling in when the coal was removed, so they would not get out sufficient coal to let the top come in. I have been in such places, and found the roof still standing, the coal having been got out a century ago.

With our modern notions of mining, these places are frequently opened again, and the remainder of the coal got out.

The cause of the second, viz., working on the face, doubtless arose from the fact that they could get the coal with a great deal more ease than any other way. Indeed, with their tools, we than could not expect them to get the coal in any other way on the face. This became a recognised principle, and if a person had thought of working in any other way, he would have been looked upon as mad. I find in the book, "*History of Fossil Fuel*," page 244, the author says on this subject—"In proceeding to get coal, the collier, whenever he can do so, works upon the face of the bed. . . . . The opposite course would manifestly be little less absurd than that if a person who, having to demolish a mass of masonry, in which all the brick were laid lengthwise upon, and in courses parallel to one another, should pursue his operations in that direction which only presented the ends of the bricks."

Through this may be seen the cause of working on the face, but observe the absurdity of the analogy. That to work otherwise than on the face would "be little less absurd than that if a person, who, having to *demolish* a mass of masonry," &c. Now, if the coal was got out for the simple purpose of *removing* it from its bed, then the

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analogy is good; but if the coal was got, which it ever was, *for its own value*, and produced as a *commercial commodity*, then the analogy is false, and consequently the argument bad. Nevertheless, it serves to show us the firm hold an established line of action may possess, whether it be true or false.

Coal, being a commercial commodity, has a representative value. It will follow, then, that the more of representative value there is, the more value will it represent. (This has reference only to quantity.) It is manifest, then, that if a quantity represents a certain value, a less quantity will represent a less value, and any quantity taken from the stipulated amount leaves the value that much less.—Any coal left in a working seam means a loss of the value it represents.

Again, coal having a representative value; as the markets are at present, this value is lessened by *condition*, quality remaining the same. I say *lessened* by condition, *because* we never find the coal in the bed in that condition that is of least value in the markets; but *make* it so by our manipulation, in quantity less or more according to the skill, or want of it, that is brought to bear in the operation of actual coal getting.

Coal having a certain value, is the owner of an estate, or the lessee, able to compute and fix at once (assuming the acreage and quality proved) the value of such estate of coal? No; neither the owner, nor the lessee, is capable of this. First, for the reason that governs all commercial commodities, viz., the ease, or otherwise, with which it is brought into its own markets. But there is another special difficulty in the way of ascertaining the approximate value of the coal, treating the estate as a whole. This uncertainty causes a deal of trouble in negociating for an estate of coal, and necessitates a great amount of care in the drawing-up of a lease for the working of coal. This difficulty is so great that in some parts of the country the lessor refuses to take any risk in the uncertainty, preferring a certain fixed sum per acre of surface measure, which involves upon the lessee the whole risk; and instances are not wanting where this kind of a "take" has ruined the lessee. This state of matters has arisen from the slovenly way in which the coal has been worked by lessees, viz., working a portion, and leaving the rest underground—lost to the owner, the lessee, and the country.

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Why all these difficulties? Why the coal lost? Manifestly from the idea "that to work out all the coal would be to let in the superincumbent strata:" hence a portion of coal is left to support it. Owners of mineral property, and their agents, are quite aware that the portion or quantity left depends upon those who have to work it: consequently he refuses to depend upon the "slipshod" work of any person who may be put to extract the coal. There is on the face of this a tacit understanding that the quantity of coal left in and lost depends upon those who work, or have the direction of working out the coal. If this reasoning is right, the idea and practice of leaving coal pillars to support the roof may be questioned. But to go beyond ideas and arguments, are there any data to bear out these matters practically? I answer, we have data in abundance that it is *not necessary to leave coal pillars to support the roof.* We have instances in various parts of the country where all the coal is worked out, and nothing left but just enough round the shaft to prevent the sides from breaking. A very prevalent, and with some people very potent objection, is the *difference* in the roof. With all due respect for such people, I feel free to make the statement, that there is *not* that difference in roofs we hear so much of. There is a great similarity in the overlying strata of all the workable seams of coal in the English coal-fields.

I have carefully looked over a number of sections from all the coal districts; I have also seen one or more working seams in each separate coal-field in England; and have, as a rule, found a bind roof, with a very few sandstone roofs, and now and then a softish, incoherent loam, varying from a few inches to four or five feet between the coal and bind—the two latter quite the exception, and bind the rule; of varying thickness, but frequently above twenty feet, very rarely less, except when it is succeeded by a layer of sandstone.

A glance at the sections of a few working seams from the various districts, will enable us to see the kind of roof to these coal-beds; and representing, as they do, districts so distant, will show us that there is a very near approach to uniformity in the overlaying strata or roofs to all working seams. Such being the case, to what shall we look for all the difference in the coal roofs we hear so much of? My answer would be simply, "*to the treatment the roof receives.*" I do not

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look upon the roof as the *active*, but as the *passive* agent; or, in other words, the roof does not act, but is acted upon. And the greater portion of coal roofs receive their character as good or bad, not from the kind of material they are composed of, but from the results of their treatment. And what would be called a bad roof, with different arrangements would be a good one. By these arrangements I do not mean propping or timbering. Props have only a temporary place and use in coal-mines, and should not be looked to, or depended upon, as permanent supports of working places. If it is desirable to keep the roof up in its place, then follow as near as possible our ancestors; but if the object be, as to my mind it ought to be, to get the coal out, then the better course is to facilitate as much as possible the falling and general resting of the roof. But to bring this part of my paper to a close, I will state in one sentence—

That the systems of working coal, as at present practised, do not depend upon the nature or condition of either the coal or roof, but upon the mining education of those who have the management.

This, to my mind, appears the *primary cause* of the different systems of working coal, and not the alleged difference in roofs, coal, floors, &c.

Another cause, but more remote, and one that has more to do with the condition or quality, as distinguished from quantity or cleanliness of get, is a matter of management—namely, in very many places the person who has the management of getting the coal has nothing to do with anything else, and knows nothing of the commercial department, or requirements of the trade; his sole object being to get the coal as economically as possible, having no regard to quality. And on the other hand, there is some one in charge of the commercial department who has nothing to do with, and knows nothing of, the productive department, and who takes charge of the coal as it comes to bank; so that, whatever may be the requirements of his trade, he has to take the coal as it is, and seek markets to suit the condition of the coal as it comes into his hands, as a matter of course.

This is a cause that affects condition and quality.

Ventilation.—The causes of different modes of ventilation are attributable more to the systems of working coal than anything else I have been able to discern. This subject is looked upon as a very important one, which, indeed, it is, and has been much written about and discussed.

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Amateurs have also made all kinds of suggestions to render this apparently difficult department more simple and effective.

I advisedly say *apparently* difficult department. I admit it is difficult, but mostly, when rendered so, by the system of working. Ventilation of coal mines is not mysterious; it is conducted on well-known natural laws. And the difficulties present themselves in degree only as these natural laws are violated by the system or mode of working the coal, and impeded by our disregard or ignorance. As at present practised, ventilation is only a secondary question, and is made, or, in many cases, only *attempted to be made*, subservient to any and all modes. Is this good policy? I answer, it is not; but in deep fiery seams it is very bad policy, and not good in any coal workings. The causes of different modes of ventilation, so far as I can see, are—First, mode of working the coal; and second, ignorance of the requirements of coal workings, and of the natural laws to facilitate efficient ventilation.

On the motion of Mr. Eccles, seconded by Mr. Darbishire, the thanks of the society were voted to Mr. Warburton.

The Chairman, in putting the resolution to the vote, said: I have felt it desirable that we should have a fair share of papers on mining subjects this session, and Mr. Warburton kindly responded to my call, and has prepared and read here to-day a paper, which, I am sure, is very instructive and valuable. Nothing can be of greater importance to a commercial community like this than a good and cheap supply of a material upon which we all depend so much, as coal, and any information bearing upon this subject must be well worthy of attention. I shall be glad to hear any remarks which gentlemen may have to make upon the paper.

Mr. Johnson: Did I understand Mr. Warburton to say that there were no bad roofs in coal-mines?

Mr. Warburton: Pretty nearly that, but I think I did not go so far as to say "none." I may mention that not long ago I was visiting a colliery by arrangement, and on my saying to the man in charge, "Why don't you work this seam," the reply was that the floor was very bad, there being about a foot of soft material. In my opinion that would be a good floor.

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The Chairman: Did he cease working the mine in consequence of this foot of soft material?

Mr. Warburton: He had ceased working it.

Mr. Gilroy: I presume that was an exceptional case, and that you would not, in consequence of it, condemn men in charge of mines generally—men of experience I mean—who complain of bad roofs and bad floors?

Mr. Warburton: I do not wish to condemn anybody so far as that goes, but can only say in reply that I have been shown seams which it was said could not be worked owing to the roof, and which, to my knowledge, have been subsequently worked upon a system said to be impossible, and the roof under that system has been considered good.

Mr. Gilroy: You have seen a seam of coal worked—one area, one block of coal, in fact—wherein one portion of the mine the roof was very bad, and in the other it was very good, whilst the same system of mining has been pursued?

Mr. Warburton: Yes; but is it not possible that a change of the system on one side would have affected the roof?

Mr. Gilroy: The same system was pursued throughout, and yet the roof of one portion of the mine was bad, and that of the other portion comparatively good. Would you recommend a change of system where the roof was bad?

Mr. Warburton: Yes; a change of treatment, by position or system.

Mr. Livesey: I have known a pit roof work very well at one time, and yet, at another time, under a different underlooker, the work has been done so that before many hundred yards were driven the air roads were blocked up. He took the chipping down. If the chipping had been left, the whole of the coal might have been got.

Mr. Livesey, jun.: I rather demur to Mr. Warburton's supporting the longwall system, and then telling us that there are no bad roofs. Though some of the roofs in this part of the country come down in fair-sized blocks, he does not think that they are unfit for *goaf* roads. One or two weeks' exposure to the atmosphere will cause them to crumble and fall, and the roads will come in; and thus, though they come down in large blocks, showing no ill-treatment so far as mining operations are concerned, they are bad roofs to all intents and purposes on the longwall working system.

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Mr. Warburton: Is there not a limit to the action of the atmosphere in roads? Does it continue to penetrate, and bring the roof off time after time?

Mr. Livesey, jun.: So far as to make an unworkable road of it.

Mr. Gilroy: In the Arley mine at Wigan, at a depth of something like 800 yards, the manager, before he can have decided upon any system of working, finds in driving merely a pair of levels that the floor and the roof came together solidly in very short time. I presume that the management in that case do not make the roof bad?

Mr. Warburton: Were I driving places 800 yards below the surface, I should expect the roof and floor to meet in less than a month's time.

Mr. Gilroy: That would be a case of bad roof and bad floor, not bad mining.

Mr. Warburton: I do not think I should go so far as to say that. If you get out a small portion like that from under 800 yards of superincumbent strata, if the roof and floor did not come together, the coal from the sides would fall in owing to the great pressure.

Mr. Gilroy: The object of my remark was to show the difficulty of deciding upon any mode of management or plan of treatment that would obviate that, and make a good roof of what is at present a bad one. I should like to hear Mr. Dickinson say something on that point, as he has lately been in the district referred to.

Mr. Dickinson: I will put the same question to Mr. Warburton as I did to Mr. Gilroy and Mr. Brigham, when we were lately looking at this roof more than 800 yards under the surface: Have you had any opportunity of forming an opinion as to whether, at such a depth as that, it would be desirable to take out the whole of the coal even from round about the bottom of the shaft, and so make your roads altogether in gob?

Mr. Warburton: I have not had an opportunity of forming an opinion at that depth.

Mr. Dickinson: At any considerable depth?

Mr. Warburton: At 500 yards, the result of my observations is that at great depths I should clear the coal right out often, without leaving shaft support, inasmuch as we cannot keep up the roofs with that pressure. If we try to keep the roof the atmosphere acts

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upon it, and the addition of the pressure, vertical and lateral, is sure to bring in small roads at great depths.

Mr. Dickinson: No doubt of it. This pressure is acting perpendicularly; you do not find it acting upon the sides of the shaft. The sides stand all right, but directly you put out a horizontal gallery, the crushing takes place, and the coal is ground to powder. The question is whether, under such circumstances, it may not be necessary to experiment as to whether the whole of the coal should be taken away even from the shaft bottom, and the pit be made to sit down, "that being the plan adopted for centuries in many of the long wall collieries in South Staffordshire"?

Mr. Livesey, jun.: Would you venture to take all the coal from the bottom of the pit?

Mr. Dickinson: I do not venture anything except to put the question.

Mr. Warburton: I would not like to be the first to take out all the coal from the bottom of the shaft, yet I would not say that it would be very detrimental to the shaft.

Mr. Livesey, sen.: I rather object to the idea that it is the weight which causes the difficulty. Suppose you took all matter from all round the bottom of a new shaft, it would not settle from the top at a depth like that of which Mr. Gilroy speaks. The crushing is not from the weight, but from the expansion of the mine. It has been crystalised, like ice upon water, and is fixed in its position without room to expand; but when an opening is made their expansion of the strata is the result.

Mr. Gilroy: Your idea is that the settling becomes arched and chokes the opening up?

Mr. Livesey: The settling would not occur until many acres were taken out.

The Chairman: It would be interesting to know whether the surface is found to subside to the extent which the mine crushes.

Mr. Dickinson: There is no doubt that when you take out a great depth, the surface settles.

The Chairman: Do you know it from observation or theory?

Mr. Dickinson: I have seen it where it can be measured by water?

Mr. Livesey, jun.: My experience is against you.

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Mr. Dickinson: There are many instances, where it has been measured by almost the full thickness of the seam, and in others at, say, one-fourth less; and if it were left long enough, perhaps the subsidence would correspond fully with the thickness of the coal removed.

Mr. Livesey, jun.: There are mines where it does not amount to one-half or one-quarter the thickness of the seam.

Mr. Dickinson: If you prop a thing upon pillars, of course it does not settle.

The Chairman: You would scarcely expect the surface to subside to the extent of what is taken out from beneath, because a quantity of foreign matter is put in.

Mr. Gilroy: There is also the upheaval of the floor in the gob.

Mr. Dickinson: The superincumbent strata are pressed down to the floor, and so fill the road up.

The Chairman: Where you get a rising in the surface at one part, you get a depression in another. I should have been glad if Mr. Warburton had said something more about ventilation—given us some recommendations as to how that important object should be effected.

Mr. Warburton: I have avoided entering into details on that subject, in order to make my paper short.

Mr. Gilroy: I think Mr. Warburton says that ventilation is made a secondary object. Very much depends upon the construction placed upon that. Of course, if a certain plan of working is adopted, ventilation must adopt itself to that plan. I presume that is the extent of Mr. Warburton's meaning?

Mr. Warburton: Yes; I mean to say that very often defective ventilation is the consequence.

Mr. Gilroy: You think ventilation a matter of too much importance to be considered secondary to any mode of management. It is the first thing a man looks to in laying out workings, or ought to be.

Mr. Warburton: It ought to be.

Mr. Wild: I would ask Mr. Warburton if he would recommend the getting out of the whole of the coal under buildings in a town, supposing the seam to be four feet thick, and the depth of shaft 200 yards?

Mr. Warburton: I would either leave half, or get the whole. My

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experience is that, by leaving half, you leave the buildings undisturbed. I may say that I have seen cottage property undermined at a depth of 90 yards; which, on the coal being taken right out, has subsided, but everything has remained in the same relative position, and the property was not injured, the coal got being six feet thick.

Mr. Dickinson: In what part of the country were these old workings where nearly one-half was taken out?

Mr. Warburton: In Barnsley, and also in South Wales.

Mr. Dickinson: I have seen some of the oldest workings in various parts of the country, and the prevailing system seems to be to work them on what you call the stoop and roof plan, taking out three-fourths of the coal. They have sacrificed one-fourth in pillars, apparently for the purpose of keeping up the roof and saving timber.

Mr. Livesey, jun.: I had occasion to go through some very old workings a short time ago, and I found that they had taken the coal away very cleanly indeed, leaving very small pillars.

Mr. Livesey, sen.: I recollect going into some old workings about Birtle, and there the workings were about three yards wide, and one-and-a-half yards of pillars were left. They were all standing.

Mr. Binney: In Scotland there is the ten-feet splint coal, that was wrought about 200 years ago. One-third of the old coal is left in pillars, two-thirds having been taken away. Those pillars appear to be as firm as any splint coal now.

The Chairman: Has the floor risen much?

Mr. Binney: Very little. It has been an outcrop, only 8 or 10 yards deep, and perfectly dry. The coal does not appear to be in the slightest degree changed.

The Chairman: If there had been a greater thickness of superincumbent matter, the result would probably have been very different.

Mr. Dickinson: That kind of coal is very hard.

Mr. Binney: As hard as iron almost. You might build a house of it.

Mr. Wild: In the two-feet seam at Barnsley, 480 yards deep, pillars two yards thick were originally left between three-and-a-half yards' work and four-feet work, and the pillars are quite solid after twelve years' working.

The Chairman: It must be a very good floor there.

The discussion upon the paper then terminated.

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MANCHESTER GEOLOGICAL SOCIETY.

A Monthly Meeting of the Society was held on Tuesday, Feb. 22nd, at the Museum, Peter-street, J. Aitken, Esq., F.G.S., President, in the chair.

The chairman having inquired if any gentleman present had any remarks of geological or mining interest to make, or any specimens to exhibit, said: According to announcement in the circular, the first paper to be brought before the meeting to-day should have been one entitled, "Observations on Some Specimens of Silver Ore from Nevada, by Mr. Moss Fletcher; communicated by the president." I may state that I am in possession of that paper, but the specimens of silver ore which should have been here to exhibit to the Society, and without which the paper would be of little interest, have not come to hand, owing to Mr. Fletcher being suddenly called away to London; and hence I deemed it advisable to defer the reading of the paper till a future meeting.

Mr. James Eccles was then called upon to read a promised paper, "On Some Starfishes from the Rhenish Devonian Strata."

On some Starfishes from the Rhenish Devonian Strata.

In the early part of last year, through the kindness of a friend residing in Germany, I received a number of Starfishes of different genera and species (which are now exhibited), which had recently been obtained from the Lower Devonian Strata of Bundenbach, in Rhenish Prussia, from the subdivision named by Ferdinand Roemer, "Aeltere Grauwacke Schiefer."

I was not then aware of the fact that two genera of Starfishes (Protaster and Palæaster), had been found in the English Devonians; and being struck by the great resemblance of some of my specimens to certain Upper Silurian Starfishes, I had a suspicion that some error had been made either in the classification of the strata whence the fossils were derived, or in the name of the locality. That this latter is correct I am now quite satisfied, but I still think it is a subject for

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inquiry whether these particular beds are of the age that is commonly assigned to them. My first impressions on this point have been much strengthened by the remarks of Mr. Robt. Etheridge, F.R.S.E., F.G.S., who kindly undertook to examine the fossils, and his report I will presently quote.

The two genera of English Devonian Starfishes above alluded to, have been found only in the upper division of the Devonian formation—the Pilton Beds—as will be seen from Mr. Etheridge's exhaustive paper, "On the Physical Structure of West Somerset and North Devon, and on the Palæontological Value of the Devonian Fossils". (Quart. Journal Geol. Society, vol. 23.) And although the specimens obtained, which are in the Jermyn Street Museum, do not show much structure, and are not in a condition favourable for comparison, it is very evident that these Bundenbach, so-called Lower Devonian, genera and species appear to have a much closer relationship to the Upper Silurian than to the Upper Devonian forms.

This fact taken in connexion with the almost total absence of Silurian species in Devonian strata, is significant,—*Atrypa reticularis* being the only Silurian species known to be common to the two formations, if we except the few fishes found alike in the passage-beds and in the lower part of the Lower Old Red Sandstone.

Respecting these fishes, Mr. Etheridge, in the paper above referred to, says:—"No value is attached to the occurrence of many species of fish that occur in common at the top of the Upper Silurian series and in the lower beds of the Old Red Sandstone: they are locally connecting species, in the passage-beds, and do not occur higher; and the want of absolute chronological and palæontological identity between the Lower Old Red Sandstone and Lower Devonian prevents our true correlation of the series."

In a letter to myself relating to these Starfishes, Mr. Etheridge says:—"As regards their affinities with the few we have in England, our Upper Silurian (Ludlow) forms are the nearest, save the Ophiuroid type (*Ast. n. sp.*), with the long filamentous arms, which I know only in the Lias of this country—the Ophiuroid type then with us making its first appearance. Our *Palæocoma*, like your form, is from the Upper Ludlow of Shropshire, and our *Protaster*, like *Ophiura*, is also from the Upper Ludlow of the same county. The

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both strongly resemble your specimens, but no structure can be made out, the slate having so completely covered in and over the arm-plates and disc-markings.

"It is evident the generic names of Roemer cannot stand, *Asterias* being so well understood and different from his. It is, however, a common name, and many forms are put to its account that have to be removed."

It would, of course, be unsafe, in the absence of further evidence, to do more than suggest the possibility of a part of these Rhenish strata belonging to the Silurian formation.

That the great bulk of the strata in this district (Bundenbach), between Treves and Mayence, belongs to the Lower Devonian is unquestionable, for it comprises the equivalents of the "Spirifer-Sandstein" and the Wissenbach slates, characterised by a profusion of Devonian fossils.

Their physical relations to the Silurians have never yet been thoroughly ascertained, and it is possible that parts of these strata, which have been grouped with the Devonian through similarity of mineral character, may by their fossils be ultimately referred to the Silurian system.

I have not yet had an opportunity of examining these Bundenbach slates, but shall endeavour to do so at an early date, and hope to collect some fossil evidence bearing upon the question raised in this paper.

SPECIMENS EXHIBITED.

Asterias Asperula .....F. Roemer.....*Protaster* .....Forbes.
Asterias Spinosissima .....F. Roemer .....
Asterias Nov. Sp. .....
Aspidocoma Tischbeini.....F. Roemer.....*Palæocoma* ...Salter.

The thanks of the Society were unanimously voted to Mr. Eccles for his paper.

Mr. Dickinson: It seems to me that the transition from the Devonian to the Silurian is so slight, that it is little more than an arbitrary line which divides them.

Mr. Eccles: In the paper which I have mentioned to-day, Mr. Etheridge seems to suppose that the Old Red and the Devonian cannot

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be correlated—that the Old Red has probably been synchronously deposited, generally speaking, with the Devonian, but cannot be correlated on account of one being fresh-water deposit and the other a marine formation. I think you do not anywhere get a proper tailing off of the Silurian into the Devonian, except in these Old Red Sandstone areas.

Mr. Dawkins: Although in England, with one or two exceptions, you do not find the animal life of the Old Red going into the Devonian strata, yet in Russia you find the two groups of life side by side, a fact that seems to me to invalidate Mr. Etheridge's hypothesis.

Mr. Eccles: To some extent that is the case in the Rhenish provinces—you there find fossil fish that occur also in the Old Red in England, in some of the higher beds of Devonian.

Mr. Dawkins: I should say that the difference between the Old Red of England and that of Germany does *not* consist in one being of fresh and the other salt-water formation.

Mr. Dickinson: I think if Mr. Binney were here he would contend that they are all salt-water formations from the Coal-measures downwards.

Mr. Dawkins: In sandstone formations you seldom get any large amount of shells. If these did exist they would have been dissolved by the carbonic acid in the rain-water. I think it very unsafe to infer that the peroxidated deposits are of fresh-water origin, simply because they do not contain many fossils.

Mr. Dickinson: A physical observer going over the country, and having an eye to the general character of the rocks, cannot say where the Devonian ends and the Silurian begins, or the Cambrian beneath it. It is a mere arbitrary line.

The Chairman: Do you mean to say that the Old Red is characterised solely by a fresh-water fauna?

Mr. Eccles: Mr. Etheridge takes up that line of argument. There is one fact hard to get over, and that is against the actual dovetailing of that Silurian formation into this Devonian. There are only four fish in the passage beds which occur in the Old Red to take it out of that area, and going directly into the Devonian area. You only find one fossil that goes from the Devonian into the Silurian.

The Chairman (referring to specimens exhibited in illustration

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of the paper): Everyone must be struck with the similarity between the enclosing material of these and that of Silurian fossils.

Mr. James Spencer then read a "Sketch of the Geology of the Parish of Halifax."

Millstone Grit Rocks.
BY MR. SPENCER.

Introduction.

The Millstone Grit Rocks are generally so homogeneous in structure, and so devoid of organic remains, that but few geologists care to study them. Elementary text-books pass over them with a mere cursory glance at their name, character, and thickness. It is very rare to find any Millstone Grit fossils in the hands of local collectors; and even museums, situated on or near the Millstone Grit Rock, such as Leeds, Bradford, and Halifax, do not contain a dozen species amongst them from this rock. This paucity of Millstone Grit fossils is not so much owing to their scarcity as to the bad state of preservation in which they are generally found; the same fossil plants, and for the most part of the same species, being found both more plentiful and in a better state of preservation in Coal Strata and Flagstone Rock. Hence the student looks in vain for aid, either to books, or museums, or collectors, in deciphering these Grit Rocks. We ought to know their character and order of succession, and of what materials they are composed; and we ought to be able to define with something like precision their boundary lines between the Yoredale Strata below and the Coal Strata above.

The want of exact information on this later point has led to many disputes concerning the position of the Hebden Bridge Shales, which abound in marine remains, such as Goniatites, Nautili, Pectens, and other well-known limestone fossils.

Some geologists say they are Millstone Grit Strata, and hence their fossils are called Millstone Grit fossils; while some persons think that they *may be* Yoredale Strata. I have heard many strange conjectures about these limestone nodules, as to how they came there. Some persons think they are boulders of limestone, brought down by floods and deposited along with the shales. Now, a careful examination of

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these rocks would solve all these questions; and I hope to be able to show you to-night the true order and succession of these Grit Rocks, and the relation which they hold to the Yoredale Strata below them, and the Coal Strata above.

Though from the first beginning of my study of geology I determined to know the lithological as well as the palæontological part of the subject, yet, owing to the dearth of information on the Millstone Grit, and the fascinating charm which the collecting of these beautiful Yoredale fossils never fail to inspire in the young geologist, I had walked over these Grit Rocks many and many a time on my way to Hebden Bridge, and taken numerous sections before their true order and succession began to dawn upon my mind. And when at length I had grasped the main features of the group, I found it no easy task to individualise each bed of grit and shale, and to trace them across the deep valleys and wild heath-clad moorlands. For a long time I laboured under the delusive idea that there were only three beds of grit, and this led me into many a miscalculation; but I learned to trust my own experience, and then I gradually got my sections to agree with my measurements, and with the appearance of the rocks themselves.

General Sketch of the Millstone Grit Rocks.

The Millstone Grit Rocks of Halifax are bounded on the east and south-east by the Lower Coal Strata, which are crowned by the well-known Flagstone Rock. These Lower Coal-measures form a bold feature in the landscape, being elevated from 400 to 600 feet above the level of the Grit Rock. They sweep round Halifax in the form of a semicircle, from Swill Hill to Ringby, Beacon Hill, Southowram to Elland, and round by Brighouse and Rastrict to the Ainleys, near Huddersfield.

They dip to the south-east, about one yard in twenty, and gradually sink under the Middle Coal-measures of Low-Moor, which lie conformably upon the Flagstone Rock.

These Lower Coal-measures are about 600 feet in thickness, and contain two workable beds of coal,—the lowest, which is called the Soft Bed Coal, is about sixteen inches in thickness, and is about twenty-five yards above the Millstone Grit. The upper workable coal is

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known as the Hard Bed—thickness, twenty-seven inches—and it is about twenty-five yards above the Soft Bed Coal.

This is the coal which has for its floor the Ganister Rock. All the other coal beds have under them a bed of fine-grained clay, which is called Seat Earth or Fire Clay, generally of a light colour; but this Ganister is a very hard rock, unlike any other rock in our Coal Strata, and when once seen can be ever after easily recognised. Immediately reposing on this hard bed-coal there is a layer of about three inches, which is almost entirely composed of marine shells called Aviculo-pectens, and the shale above this pecten bed contains a great quantity of marine shells, such as Goniatites, Orthoceras, Nautili, Pectens, Poseidonia, Buccinum, and many other shells. I have got from this bed in Shibdendale alone upwards of fifty species of marine shells and fish remains. The Coal is in no way affected by this marine strata; and by whatever means THIS influx of sea-water into the coal-field was brought about, this we are certain of, that no great disturbance took place, and these marine shells testify to the very slow and tranquil deposition of these strata.

Millstone Grit.

The Grit Rocks gradually rise from under these Coal strata, and occupy all the extensive parish of Halifax, north-west of the above range of hills, with the exceptions of the deeper portions of Calder-dale above Hebden Bridge, and the valleys of Crimsworthdean and Hebden.

As we go to the north-west we see bed after bed rise to the surface, until we come to the lowest bed or Pebbly Grit, from under which rises the Yoredale Shales of Hebden Bridge, and the deep valleys north-wards.

The succession of the Millstone Grit Rocks is upon the whole very regular, and free from any very large faults, the greatest that I am acquainted with not being more than fifty yards. There are, however, many minor ones, and bendings of the strata, especially in the moorlands north of Hebden Bridge.

The general trend of the strata is from N.W. to S.E. They dip about one yard in twenty-one yards, which is nearly the same as the dip of the Coal strata. To illustrate this dip or inclination of the

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strata more clearly, the Lower Pebbly Grit of Heptonstall is about 900 feet above the level of the sea, while the upper bed, or Rough Rock of Halifax, is 300 above the sea level: the thickness of strata between the Lower Pebbly Grit and the top of the Rough Rock is about 1,400 feet, which gives a fall of 2,000 in the eight miles from Heptonstall to Halifax, being at the rate of about 250 feet per mile, or about one yard in every twenty-one yards.

As we approach the apex of the Pennine Chain, which bounds the parish of Halifax on the north-west, the strata becomes very much undulated, and numerous faults, contortions, and bendings occur, and the strata dip for some distance at right angles to this great fault. There is another great fault, or anticlinal, which runs at right angles from the Pennine Chain across the moorlands of Heptonstall, Midgley, and Warley in the direction of Swill Hill, which causes the strata to dip to the south for a considerable distance. This is the reason why, in going up Luddenden Valley, which runs to the north and at right angles to this lateral ridge, we get lower and lower in the strata, until at Castle Carr the Lower Pebbly Grit rise to the surface.

In the same manner, as we ascend Cragg Valley, from Mytholmroyd, which runs up to the south, and at right angles to the Pennine Chain, we find at St. John's the Lower Pebbly Grit, which there rises in the form of an anticlinal.

You will be able to understand by this, that it is only when we get well away from these disturbing causes that the strata begins to have a decided dip or inclination to the south-east, and that even then the dip is liable to be affected by the faults which occur in the strata; but this is only for a limited extent, and in taking the dip for a few miles we need take no notice of them, unless they happen to be very large ones.

The thickness of the rocks shown in the section is as follows:—

	Feet.	
Flagstone Rock	70	
Lower Coal-measures	630	
		700
No. 1 Rough Rock, about	100	
1' Shales	300	

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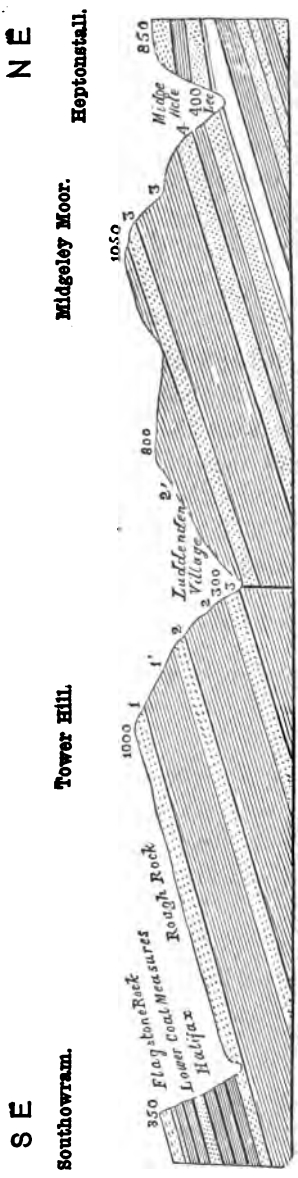

STRATA OF HALIFAX.

No. 2 Grit, Grey Grit of Rocking Stone...	80	
2′ Shale	350	
No. 3 Grit or Galliard Rock, with Coal Strata	100	
3′ Blue Shales	450	
No. 4 Pebbly Grit	120	
		1500
Yoredale Strata.....	600	600
	2800	2800

This section is taken from the base of the Lower Coal Strata of Southowram, just below the railway station. It runs across Halifax by Highroadwell to Tower Hill, overlooking Luddenden Valley, then across the valley, by way of Midgley and Wadsworth, to Heptonstall. It runs in the direction of the dip of the strata—from north-west to south-east. It is drawn to a scale of six inches per mile in length and 200 feet per inch in height.

There are four beds of Grit Rocks separated from each other by thick beds of Shale.

The uppermost bed, upon which Halifax stands, is equivalent to the Rough Rock of Lancashire. The Rough Rock is bounded on the south-east by the Lower Coal-measures, under which it sinks. It extends to the north-west as far as Mount Tabor. I have taken numerous sections in this rock, but the two following will suffice to show its composition and thickness. The

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first section I have taken recently at the town's quarry at Mount Pleasant:—

	Feet.
Soil	1
Rubble	4
Soft Sandstone	20
Hard rock, very variable, used for paving, &c.	56
Thin-bedded Micaceous Flagstone	15
	96
Shale below.	—

There are no beds of Shale or Clay in this Rock; it is of very variable quality, but a great quantity of good stone is extracted from it. The thickness of rock in this quarry is the greatest that I have seen exposed of the Rough Rock. Below this rock there is a bed of bluish Shale, from ten to twenty feet in thickness, and under this Shale beds of Rag and Micaceous Flagstone. Both the Shale and Stone below it increase in thickness as we go to the north-west.

Rough Rock and Shales below.

This bed of Shale and Flagstone below extend all the way up Wheatley Valley. At Throggs Wood, on the side of the new road leading to Wheatley, the Shale under the Rough Rock is about ten feet in thickness, and the Flagstone underneath is from six to eight feet. If we trace these two beds up the valley, we shall see them gradually increase in thickness. In the quarries opposite Mixenden, the Shale is about twenty feet thick, and the beds of Rag and Flagstone are nearly thirty feet in thickness.

Here the Rough Rock is almost worthless, but the Flagstone below this Blue Shale is very valuable, and it is worked both by open quarries and by mines. The following is a section of one of these quarries:—

Rough Rock	50 feet
Fine Blue Shale	20 „
Ragstone	8 „
Micaceous Flagstone	20 „
	98

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The Flagstone group below the Blue Shale increases in thickness to about forty feet in the quarries on Hunter Hill, on the opposite side of the valley. This Shale and Flagstone group, below the Rough Rock, is one of the many cases which illustrate the fact of the thickening of the strata towards the north-west. Many and many a time have I traced a bed of Sandstone, which begun in a point, perhaps, not more than one inch thick, but in going up the valley to the north-west, or in the direction of the rise of the strata, it gradually increased in thickness until it reached a thickness of eight or ten feet. There are very many cases of this kind in these Grit Rocks; but I have never met with a single instance of the beds thickening in the contrary, or south-west direction.

Shale below Rough Rock.

The Shale between the Rough Rock and the next Grit Rock is from 250 to 300 feet in thickness. It occupies the deep valleys of Wheatley, Ogden Cloughs, the Calder from Sowerby Bridge to below North Dean, Stainland, and the upper edge of Luddenden Valley. The details of this Shale may be best studied in the scar opposite Birks Hall, under Throggs Wood, and in the deep cloughs at Ogden.

They are of a dark iron-grey colour, with layers of soft clayey stone, which splits up into very thin laminæ. This scar very much resembles the strata of Mam Tor (Shivering Mountain), in Derbyshire, and like them they are very perishable. After a frosty night, when the sun shines on the scar, one may hear the Shales fall away and rattle down to the bottom of the scar. In very fine droughty weather I have brought down showers of fine debris by simply striking the cliff with my hammer. Nearly 100 feet of the Shale is exposed in this scar. From sixteen to twenty feet above the beck, which runs at the base of this cliff, there is a thin band of hardened mud runs all along the scar. It contains Goniatites Pectens, Modiolas, and other marine shells. The shells are not well preserved; the Goniatites are all crushed, but the Modiolas, though small, are very good. They are the same species, as far as I could make out, as those of our Shibden Coal Strata. The black band of mud, with its crushed Goniatites, is similar to a band which lies on the hard-bed Coal under Scout Hall, Shibdendale. The miners brought out almost exactly

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similar pieces, from one to two inches thick, with the same crushed Goniatites, when they were getting the coal. There I compared them at the time, and they were so near alike that I could scarcely tell one from the other.

Shale below Rough Rock.—Marine Strata.

I have traced the same band with its marine shells in the Shale at Ogden Clough, there the band is thinner; but it yielded me several species of shells, Goniatites and Modiolas being most frequent. This band also contains a ribbon-like plant. These plants vary in breadth from $\frac{1}{8}$ of an inch to $1\frac{1}{2}$ inches, but what they are I have not been able to make out.

In Wheatley Scar, I found these marine shells but sparingly both above and below the black-mud band as well as in the band itself. The whole thickness of strata containing them is about a foot. The strata for about a yard above, and all below, as far as is exposed, is of that peculiar dark reddish lustre which is generally barren of fossils. It seems as if the cankerous waters, in which these Shales were slowly deposited, were not suited for animal life. But how did these shells come there in the midst of this ungenial strata? We know that these strata were deposited in a sea or large estuary which was slowly sinking; sometimes a little slower than usually; sometimes a little faster; sometimes it may have been stationary; and at others it suddenly sunk so low as to admit of sea covering the area and for a time peopling that area with marine life—fish and shells. Sometimes this marine fauna would live and flourish for a great length of time, as, for instance, during the deposition of the marine strata over the Hard-bed Coal, while at other times, the conditions not being favourable to them, they would perish. This appears to have been the case with the marine shells in this dirt-band. The Goniatites appear to be full-grown individuals, but they are all broken up or crushed as if they had perished after an ineffectual "struggle for existence." But perhaps the same band, if we could trace it some miles further to the east or south, would yield fine specimens and a better variety, like the parellel case of the dirt-band in the Shibden Coal Strata.

Ogden Kirk—Petrified Moss.

Below Ogden Kirk there is a spring which deposits carbonate of

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lime, forming some beautiful petrifactions of moss and lichens. It is nearer the Rough Rock than the dirt-band. There is no compact layer of Limestone that I have been able to find; but I think the Shale may contain a large percentage of Lime, and the water percolating through it, carries with it an excess of Lime which it deposits on the moss which grows luxuriously near it. Some years ago a friend brought me a small stalagmite, composed of fine Sand and Lime, which had been deposited near Kirk's Dyehouse, Old Lane, Halifax, under the Flagstone below the Rough Rock. It would seem from this that the strata about the Flagstone rock contains a large percentage of lime. Indeed, I have found a good deal more Lime in these Grit Rocks than I expected, and I should not be surprised to hear of more marine fossils being found in other parts of the series besides the thin band which contains them in Wheatley Scar. The following is the list of the fossils which I obtained from this place :—

Goniatites, Listeri, Gibsoni, and others.
Nautilus—Two specimens, and one doubtful.
Pectens—One specimen, a small one.
Poseidonia, Venus ? } Two or three specimens.
Modiola—plentiful: similar to those of Yoredale Strata.
Aviculo-pectens—One large specimen.
Plants and fruits.
Coprolites and fish scales.

At Mixenden we meet with Grit Rock No. 2. It is composed of two beds: one of them is of a red colour, in places a deep red; the other is a beautiful white grit, in which the small grains of quartz sparkle like silver.

Large blocks of this white grit may be seen scattered about the fields above the village of Mixenden. If we mount the steep slope of Hunter Hill, which is composed of Shales No. 1, we see that the summit is capped with the Rough Rock, and the Flagstone group underneath it. Going down the other side, we come across Grit Rock No. 2, at Lumb Mill, and we walk along the top of it on Warley Moor to Stoney Edge, where we see again this characteristic white grit. A little further on, we come to the celebrated Rocking Stones, which are the western outcrop of this rock. They are blackened by

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the elements, and have a venerable look about them; but upon breaking a piece off we see that it is the same Red Grit Rock. These "Rocking Stones" are thought by antiquarians to be the remains of a Druid place of worship. The main rock appears, when looking at it from the west, like a large misshapen mushroom. The stalk is formed of a great many thin layers of Sandstone, while the cap is formed of a large block of grit, the upper surface of which contains between twenty and thirty "basins," or "pan-holes." These pan-holes are of all sizes—from the largest, which is about thirty inches deep and between three and four feet diameter at the top, to the smallest, which is about the size of a cup. There is no regularity about their size or shape. The stone is leaned against the main rock, but there is a narrow passage between the stalk and the rock which a man can creep through. There is no appearance that this stone ever "rocked,' but the stone which did rock, it is said, lies near, having fallen down.

This No. 2 Grit is continued northwards as far as Fly Quarries, where it forms a valuable building stone, and we can trace it all down Luddenden Valley to below Luddenden, where it forms a prominent ridge along the middle of the hill-side on the east of the valley. It is worked in many places. The same rock is continued as far as Friendly and Sowerby Bridge. As it gets further south from Rocking Stones, it loses its characteristic features of colours, and becomes an ordinary pale Sandstone.

This rock forms a good datum line from whence to trace the succession to the next Grit. The Shales below this rock occupy the slopes on each side of Luddenden, from this rock to the water-edge below Booth to Luddenden Foot. As far as I have seen of them, they are a light sandy colour; but they are almost all covered by vegetation, so that little of it has come under my observation. Proceeding from Rocking Stones, down into the valley near Castle Carr, we see a Sandstone quarry in the moor on the road side: this is Grit Rock No. 3. Here it is about sixty feet thick, and forms valuable building stone. Proceeding still lower down into the valley, we see some coarse, massive grey rocks lying in the fields about fifty feet above the lower reservoir, and just opposite the Castle. They are dotted here and there with round patches of moss and lichens. This is a feature which is very characteristic of the Lower Pebbly Grit Rock, and I

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could almost recognise it by that alone. This is the Pebbly, or No. 4 grit. Some of its beds contain a large percentage of lime: hence the partiality of moss and lichen germs for it. It is brought up here by a large fault. The Castle—the shooting-box of Sir Henry Edwards—stands upon a great landslip. The No. 3 Grit, upon which it stands, has slipped down upwards of 200 feet from its original level. The same rock may be seen on the moor edge, overlooking the Castle on the west. Owing to this landslip and the large faults, the strata is very complicated here; and it took me some time before I could make out the true position of the strata in the cutting for the puddle dykes which was dug for the reservoirs here, in which were found a number of marine shells.

I shall give a list of these interesting fossils at the end of my paper. The strata is undoubtedly below the Lower Pebbly Grit, and therefore Yoredale. But the matrix in which the fossils were embedded was a quantity of peculiar light earthy nodules, so soft that the shells could be picked out by the fingers. They were beautifully preserved, and came out as plump and fresh as if only entombed the day before. It is a great pity that more of them were not secured; and we are deeply indebted to Mr. G. Rushworth, of Hippenholm, for securing the few that came out.

But to return to the No. 3 Grit. I have traced this rock from Luddenden Foot to Luddenden, where it may be seen on each side of the beck. From Luddenden it gradually rises in the valley, until at Castle Carr it forms the cap of the moors on each side. There are many small faults and undulations of the strata to be seen in this valley. I have also traced it from Luddenden Foot to Midgley, and thence over Wadsworth to the moor above Becket Well, and across the moor from Castle Carr to Becket Well. There are many quarries in this rock along the edge of Calderdale, from Midgley to Becket Well. This rock has two peculiarities, which distinguish it from the other Grit rocks. The first is that it contains several beds of Coal and Coal Shale; the second is that it has a peculiar bed of fine-grained Siliceous Stone—a kind of Galliard, which the delvers call "calley stone." It is a very hard stone, and is used as road metal.

I have traced the Coal Strata both up Luddenden Valley, and from Midgley to Wadsworth. There are many old mines in the latter

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place where Coal was got about thirty years ago. It is said the bed was ten inches in thickness; but the thickest bed of coal that I have seen in this rock is only about six inches; it has under it the usual bed of seat-earth. The following is a section of the old quarry above Midgley containing the Coal-bed :—

	Ft.	In.
Rubble	16	0
Thin-bedded Stone	24	0
Coal-bed	0	6
Seat-earth	4	0
Thick-bedded Pebbly Sandstone	30	0
	74	6

It is probably much thicker. Dip, about 3 deg. S.E.

The lower part of this rock is a coarse Pebbly Grit, and it is remarkable on account of the amount of disintegration which it has suffered at the edge of this old quarry. For four or five feet into the face of the solid rock, it has crumbled away into sand. Doubtless this is the effect of the westerly gales, which beat with powerful force against the eastern edge of Calderdale. At Skip Mount, near Wadsworth, I took the following section :—

	Ft.	In.
Debris	8	0
Sandy Stone	8	0
Dark Bluish Shale *	5	0
Layer of Coal	0	2
Shale	5	0
Galliard Rock	16	0
Grey Shale	1	0
Layer of Coal	0	2
Thick bed of Stone, upper streaked like Ganister	6	0
	49	4

No bottom visible. Dip 8 inches to the E.

* This Shale increases from four feet at south of quarry to ten feet at north in about twenty yards; but whether it be its natural bed, or there has been a landslip at the south end, I cannot tell. The section is as accurate as I could possibly take it, for I took great care with it. There is no bed of Seat-earth under either of these coal-seams.

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The Shales between this Galliard rock and the Lower Pebbly Grit, appear to be between 400 and 500 feet in thickness. The upper part of them are very like the Coal Shales at Low-Moor or Middle Coal-measures; and, taken in conjunction with the rock above, it forms a remarkable example of a coal-field in the Millstone Grit Rocks. In fact, these Coal strata were formed under similar conditions to the real Coal-measures, the only difference being that the land was not stationary a sufficient length of time to allow of the formation of thicker beds of coal; for you must recollect that all these strata were deposited in an area that was slowly sinking, and that each bed or Coal represents a pause in the downward movement, during which the land remained near the surface of the water, and, in some cases, a slight elevation took place, so as to bring it above the level of the water; and the thicker the beds of Coal are, the greater the pauses were.

Lower Shales of Millstone Grit.

Perhaps the best section of these Shales may be seen in Cragg Valley, from Mytholmroyd to St. John's-in-the-Wilderness. The whole of this part of the valley is excavated out of these Shales. Here they are nearly 500 feet in thickness, and the whole series may be examined. They are somewhat like our Lower Coal-measure Shales, but more homogeneous in structure: the lower portion resembles the Yoredale Shales, and they have been mistaken for the Yoredale Strata by some local geologists; but I have not the slightest doubt upon the subject, for I have examined them and re-examined them. I have traced the Lower Pebbly Grit from Hebden Bridge, until it sunk below the surface before reaching Mytholmroyd, and then walked on the top of it (for the Pebbly Grit lies just below the surface all up Craggdale) up Craggdale, until I saw it rise from under the surface, and gradually ascend in the cliff by the beck side, until it rose in the form of an anticlinal at St. John's.

The Lower Pebbly Grit.

The maximum thickness cannot be less than 120 feet; but the following section, taken in an old quarry on the east side of "Midge Hole," just above New Bridge, in company with your President, Mr. will give you an idea of its composition.

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	Feet.
Upper part covered by vegetation.	
Thick Pebbly Grit.....	30
Sandy Shale	2
Calcareous Sandstone	10
Sandy Shale	2
Thick Pebbly Grit.....	50
Base not visible.	—
	94

There is a bed of Calcareous Sandstone below, which may be seen on the other side of the valley.

The Lower Calcareous Grit has been traced in many parts of the Hebden Valley; it is of a light appearance, and is occupied by many rare plants and ferns. It forms a beautiful fringe all round the romantic glen of Caldean, under Heptonstall Eaves. It is the only place where the Clausilliadnigricans has been found in our neighbourhood. The maiden-hair and other ferns court its shade.

The Pebbly Grit is most characteristic at Widdop. There the rocks are one mass of pebbles, but the same rock gets finer and finer the further we trace it to the south-east.

Millstone Grit Fossils.

The following list is taken from specimens in the Halifax Museum:—

1.—Pecopteris Serlii, Holywell Green, Stainland.
2.—Sternbergia approximata, large specimen, Stainland.
3.—Calamites cannæformis, large specimens, Stainland.
4.—Lepidodendron obovatum, good, Hebden Bridge.
5.—Halonia gracilis, good, Hebden Bridge.
6.—Favularia, Hebden Bridge.

In my wanderings up and down the deep cloughs, I have met with many specimens in the rocks, but they have either been too large or could not be got out, but I have noted the following: Very large Sigillariæ Lepidodendra, many species; Sternbergia and Calamites very common; Halonia and Knorria, Stigmaria, and Lepidostrobus—the Ovenden Naturalist Society have a few good specimens;—two

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very fine Calamites, with the roots; Stigmaria, Favularia, and Lepidodendron. I have seen good specimens of what appear to belong to the Caulopteris or tree-fern.

I have not been able to obtain the number got from each bed of Grit, but as far as I have seen of them they all contain the same species. The Rough Rock and Grey Grit No. 2 are in some places rich in fossils, and probably the same may be said of the others if they had been sought after with equal assiduity.

Yoredale Fossils of Castle Carr.

Nautilus Sulcatus, 2 fine specimens.
Goniatites reticulatus, plentiful.
Goniatites, Listeri, Gibsonii, Looneyi, Spirorbis.
Orthoceras cunctum, good.
Aviculo-pecten.
Modiola.
Coprolites and fish remains.

Yoredale Rocks.

If we take the base of the Pebbly Grit as the line of division between the Yoredale Rocks and the Millstone Grit Rocks, which appears to me to be the only safe guide in this neighbourhood, we have a thickness of about 600 feet of Yoredale Strata exposed in the deep clough of Horsebridge. In this strata there are two beds of Sandstone, the first about 150 to 200 feet below the Pebbly Grit. This Sandstone is about forty to fifty feet in thickness. It is composed of beds of Sandstone and beds of Shale. Below this rock the Shales are generally of a bluish colour, but in places, of that brown lustre which is due to the presence of iron. They are generally very fine grained, and they are about 250 to 300 feet in thickness. In this Shale there are many bands of Calcareous Ironstone, and one, if not two layers, of bluish-black Limestone of from eight inches to twelve inches in thickness. This layer is split up into cubical blocks of various sizes. The upper portion of many of these blocks contain patches of fossils, and most of them have been rounded on the upper surface by the water, owing to the fossils decaying faster than the hard, irony Limestone. This band of Limestone crops out in three places in Horsebridge Clough, namely, just at the entrance at New Bridge, and at the base of a scar of blue

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Shale, called Black Scout, about half-a-mile above New Bridge, and again in a low cliff about half-a-mile above Black Scout. All these places are near the brook side. The same Limestone band crops out in the valley of the Hebden, under Walshaw. Great quantities of these nodules, or rather blocks, have been scattered up and down the brooks of these valleys, by floods washing them from their native beds, and they have furnished our local collectors with vast quantities of marine shells.

The lowest bed of Sandstone forms the apex of an anticlinal axis. This small section will illustrate this fact. Here we see that the strata of the deep valley of Horsebridge Clough dips from this central ridge on the one hand to the north, and on the other, to the south. The Sandstone at the upper end of the section represents the first Yoredale Sandstone; that in the middle is the second Sandstone, which cannot be less than 100 feet in thickness. The place where it crops out along the brook, which flows over it, forms part of a great fault, which throws the strata down to the west. This anticlinal axis flows over by a number of bendings and small faults, so that in going up the valley the strata dip for a time to the north, then to the south, and then they are horizontal, and so on till we reach the apex of the ridge. As we go up the watercourse the causes of these variations may be seen by the number of small anticlinal and synclinal axes which we meet with.

Geology of Calderdale.

The Calder runs through the parish of Halifax in a west and east direction. Taking its rise from the valleys about Todmorden, its waters are swollen by many tributaries, both from the north and south. From Todmorden to below Hebden Bridge it flows through Yoredale Strata capped with the Pebbly Grit, which in many places rise abruptly into perpendicular cliffs. Before reaching Mytholmroyd, the Pebbly Grit sinks below the surface, and the Shales above the Pebbly Grit form the surface of the valley down to Luddenden Foot. The 3rd Grit Rock, which forms the summit of Hathershelf Scout, near Mytholmroyd, sinks rapidly, until the river flows over it midway between Luddenden Foot and Sowerby Bridge. The Middle Shales, then, form the surface till we get below Sowerby Bridge. Then Grit

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No. 2 sinks below the surface, and the valley is formed out of Shales No. 1, as far as Elland, where the Rough Rock in turn sinks under the river, and the broad vale from there to Brighouse is scooped out of the Lower Coal Strata, and the hills on either hand are capped with the Flagstone Rock.

The deep dales north of Hebden Bridge, Mytholm Clough, Hebden Valley, Horsebridge Clough, and Midge Hole, are carved out of the Yoredale Strata, and bounded by perpendicular scars of Pebbly Grit.

The beautiful and romantic Craggdale is formed out of the Shale No. 3 and No. 3 Grit, and it owes its characteristic scenery to the very perishable nature of these Shales. Luddendendale presents one of the finest natural sections of the Millstone Grit Rocks that can be seen in our parish. Its scenery, especially below Castle Carr, is magnificent.

Geology and Scenery of Calderdale.

The extensive valleys of Riponden, Stainland, and Wheatley are chiefly scooped out of the Rough Rock and Shale below.

The beautiful dale of Shibden is formed out of the Lower Coal Strata.

To the various rocks which compose the Yoredale and Millstone Grit Strata, and to their yielding unequally to the various influences by which they have been effected, and the varied character of the vegetation which clothe them, we owe all the wonderful scenery of these valleys and hills.

Many and many a glorious walk have I had among these deep valleys and over these wild moorlands. But, perhaps, one of the best walks was one day last summer, when I went from Halifax across the country, in the line of this section, by way of Midgley to the moorland above Becket Well, and thence down into the beautiful valley of the Hebden. A better route could not possibly be taken for getting a bird's-eye view of the varied scenery of our moorlands and valleys. From Midgley the road runs along the edge of Calderdale, winding round many a projecting knoll and many an upland valley; the quiet vale of the Calder, here broad and deep, with its rich meadows and sylvan woodlands, strongly contrasting with the romantic grandeur of the towering crags and purple moorlands above.

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Every turn of the road opens out magnificent prospects of hill and dale, crag and moorland, and decked in all the rich and varied colours which generous nature ever bestows upon them at this season of the year, the whole deftly blended together, and forming one of the most glorious panoramas that ever gladdened the heart of the enthusiastic lover of nature.

The thanks of the Society were voted to Mr. Spencer for his paper.

Mr. Chatwood: How thick did you say Black Scout was?

Mr. Spencer: Seventy feet thick. There are a few Millstone Grit fossils on the table before you— some Lepidodendra, very like Club-mosses, and Calamites. And a few marine shells from above the Hard-bed Coal in the Lower Coal-measures.

The Chairman: I observe that in speaking of the Pebble beds, which you describe as the lowest of the four beds of Millstone Grit, you say there is a considerable quantity of Lime. Is that Lime distributed throughout the whole of the rock, or confined to the beds which lie towards the bottom portion?

A vote of thanks to the Chairman concluded the proceedings.

MANCHESTER GEOLOGICAL SOCIETY.

A Meeting of the Society was held on Tuesday, March 29th, at the Museum, Peter Street, J. Aitken, Esq., F.G.S., the President, in the chair.

Mr. John Knowles read a paper, entitled "Observations on the Temperatures of Pendleton Colliery."

Observations on the Temperatures at the Pendleton Colliery. By John Knowles.

There are two pits at this colliery, situated twenty-two yards apart. They are eight feet diameter for 480 yards, and the remaining forty-six yards, ten feet diameter. In both pits there is 150 yards of cast-iron tubing, to keep back a very large quantity of water, which is in the upper four-feet mine.

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It would be very desirable if the area of these shafts could be increased, but it would entail an enormous outlay, and probably endanger the safety of the mine to attempt to do it.

There are three seams in work, namely, the Albert mine, the Crumbouke mine, and the Rams mine, the depth to the latter being 526 yards.

Ordinary gas is used at the pit levels, and it requires a pressure of fifteen inches of water to force it down. This is accomplished by using a weighted gasholder.

The ventilation of the colliery, which is created by the use of a furnace and the fires of three underground boilers, is 92,650 cubic feet per minute; and the water pressure between the pits, when the cages are stationary, is 1·2 *inches*, but when the cages are working against the current, it is 0·7 *inches*.

The rate at which this air descends the pits is 1,850 feet per minute, or about twenty miles per hour; and when it is distributed into the workings of the mines it is divided into various currents, the speed of which varies from 140 feet to 760 feet per minute.

There are 383 men and boys employed underground, and eleven ponies.

The surface of the pits is about 126 feet above the level of the sea.

These particulars have been given to enable anyone who may have an opportunity of taking the temperature in mines to compare one series with another.

The following tables show the temperatures that have been taken at various times :—

Observations at Pendleton Colliery.

JUNE 5TH, 1866.	Perpendicular Depth.	Distance Travelled by the Air.	Temperature in Degrees Farenheit of			Increase of Temperature above 60° at 50 feet from Surface.	Increase of one degree in Feet.
			Air	Coal.	Strata.		
	Yds.	Yds.	°	°	°	°	Feet.
Top of Down Cast Pit	..	...	68	...	...	...	...
Middle „	263	263	68	...	...	...	...
Bottom „	526	526	67	...	...	...	...
500 Yards down Rams Mine Brow ...	696	1026	72	...	...	...	...
1,100 Yards on West Level	696	2126	75	...	...	..	...
800 Yards on Higher Level	648	2526	73	...	...	...	...
480 „ „	648	2846	70	...	...	...	...
Bottom of Upcast Pit	526	3676	75	...	...	...	...
Middle „	263	3939	150	...	...	...	...

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TIME.	A.M.												
	6 0	6 30	7 0	7 30	8 0	8 30	9 0	9 30	10 0	10 30	11 0	11 30	12 0
Temperature on Surface, Fahrenheit	32	32	32	33	34	35	36	37	40	48	50	50	52
Temperature Bottom of Down Cast Shaft	51	51	51	51½	51½	52	52	52	52	54	54	54½	56
Temperature of Return Air at Bottom of Up Cast Shaft	72	72	72	72	72	72	72	72	72	72	72	72	72

TIME.	P.M.												
	12 30	1 0	1 30	2 0	2 30	3 0	3 30	4 0	4 30	5 0	5 30	6 0	
Temperature on Surface, Fahrenheit	54	56	58	56	56	56	56	55	54	53	51	50	
Temperature Bottom of Down Cast Shaft	56½	57	58	58	58	58	58	58	58½	58	58	58	
Temperature of Return Air at Bottom of Up Cast Shaft	72	72	72	72	72	72	72	72	72	72	72	72	

MARCH 30TH, 1858.	Perpendicular Depth.	Distance Travelled by the Air.	Temperatures in Degrees Fahrenheit of			Increase of Temperature above 60° at 50 feet from Surface.	Increase of one degree in Feet.
			Air.	Coal.	Strata.		
	Yds.	Yds.	°	°	°	°	Feet.
Top of Down Cast Pit	...	...	32 to 58	...	...	...	...
Bottom „	526	526	51 to 58	...	...	...	...
Bottom of Up Cast	...	...	72	...	...	...	...
Bottom, near the Engines	...	...	78	...	...	...	...
Top of Engine Down Brow	...	...	62	...	...	...	...
Ram's Mine, No. 1 Level, 190 yds. down	593	716	64	...	...	...	...
„ „ 2 „ 355 „	648	881	64	...	...	...	...
„ „ 3 „ 500 „	696	1026	65	...	...	...	...
„ „ 4 „ 625 „	738	1151	67	...	...	...	...
Hole in Coal, No. 2 Level, 300 yards from Brow	648	...	75	75	...	25	75·7
„ „ in Floor	648	...	...	...	77	27	70·1
Hole in Coal, No. 3 Level, 500 yards from Brow	696	...	...	70	...	20	101·0
„ „ „	696	...	...	...	74	24	87
Hole in Coal, No. 3 Level, 1000 yards from Brow	696	...	...	83	...	33	63
„ „ „	696	...	...	...	82	32	65
Hole in Coal, No. 4 Level, 200 yards from Brow	738	...	...	80	...	30	72
„ „ „	738	...	...	...	84	34	63
Hole in Coal, No. 4 Level, 400 yards from Brow and 50 yds. from Face	738	...	...	82	...	32	67
„ „ „	738	...	...	...	86	36	60
Hole in Tunnel, at No. 4 Level, 17 yards from Rams Mine, in Metal	738	...	...	...	76	26	83
„ 62 yards in Warrant	738	...	...	...	79	29	74
„ 84 yards in Hard Rock	738	...	...	...	82	32	67
„ „ „	738	...	...	...	80	30	72

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APRIL 8TH, 1868.	Perpendicular Depth.	Distance Travelled by the Air.	Temperatures in Degrees Fahrenheit of			Increase of Temperature above 60° at 60 feet from Surface.	Increase of one Degree in Feet.
			Air.	Coal.	Strata.		
	Yds.	Yds.	°	°	°	°	Feet.
Top of Down Cast Pit	...	...	42	...	...	...	...
Bottom „	526	526	55	...	...	...	...
End of No. 4 Level, 440 yards from Rams Mine Brow	738	1151	78	...	...	...	...
„ „ „	738	...	...	82	..	32	67
Bottom of Engine Brow	738	...	67	...	...	...	...
Face of Tunnel	738	...	80	...	...	...	...
Hole in Metal Face of Tunnel	738	...	...	...	81	31	70

TIME.	A.M.			P.M.							
	10 0	11 0	12 0	1 0	2 0	3 0	4 0	5 0	6 0		
February 28th, 1870.											
Temperature on Surface ° Fah	53	55	54	55	55	55	54	53	51		
Bottom of Down Cast Shaft	58	58	58	58	59	59	59	59	59		
Return Air—Rams Mine	72	72	72	72	72	72	72	72	73		
March 1st, 1870.											
Temperature on Surface	51	51	53	53	54	51	52	50	48		
Bottom of Down Cast Shaft	58	58	59	59	59	59	60	60	60		
Return Air Crumbouke Mine	75	75	74	75	75	75	75	75	75		

FEBRUARY 28TH, 1870.	Perpendicular Depth.	Distance Travelled by the Air.	Temperatures in Degrees Fahrenheit of			Increase of Temperature above 60° at 60 feet from Surface.	Increase of one Degree in Feet.
			Air.	Coal.	Strata.		
	Yds.	Yds.	°	°	°	°	Feet.
Rams Mine, No. 2 Level, 300 yards from Engine Brow	648	1181	65	72	...	22	86
Rams Mine, No. 3 Level, 500 yards from Engine Brow	696	1526	72	78	...	28	72
„ „ 1000 „	...	2026	76	82	...	32	63
Rams Mine, No. 4 Level, 200 yards from Engine Brow	738	1351	69	76	...	26	83
„ „ 600 „	...	1751	76	82	...	32	67
Rams Mine, No. 4 Level, 930 yards from Face of Level	...	2081	79	82	...	32	67
„ „ in Floor	...	...	...	...	83	33	65
„ „ in Coal 7ft. 9in.	...	...	...	84	...	34	63
March 1st, 1870.							
Crumbouke Mine, No. 5 Level, 339 yards from Tunnel at Face	738	1605	74	...	82	32	67
„ in Coal 3 feet deep	...	...	...	80	...	30	72
„ in Coal 12 feet deep	..	..	...	82	...	32	67
„ 200 yards from Tunnel No. 3 Level.	...	1466	76	79	..	29	74
780 yards from Engine Brow at Face No. 4 Level.	661	1806	80	80	80	30	64
800 yards from Engine Brow at Face	683	1906	81	...	82	32	62
„ in Coal	...	...	...	78	...	28	71

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In the preceding tables it will be observed, that however much the temperature of the air on the surface may vary, the air when it arrives at the bottom of the down-cast shaft does not change much.

In one case it varies from 32° to 58°, and in the other from 51° to 58°.

During the winter season, if the temperature of the air be very low, fires have to be placed around the surface of the down-cast shaft, to prevent the water and dampness being converted into ice in the pit, and so stop all the operations of winding.

After the air has been through the workings, it keeps to the uniform temperature of 72° in the Rams mine returns, and 75° in the Crumbouke mine returns.

In the heat of the summer in 1866, the temperature of the air on the surface was 68°, and it cooled down to 67° at the bottom of the down-cast shaft. In this particular instance, the return air was 75°, on account of the greater temperature of the air going into the mine.

The air does not increase in temperature in descending the shaft in the same ratio as the temperature of the measures increase: viz., if we assume that the temperature of the measures would be 50° at fifty feet deep from the surface, and adding 1° for every sixty feet, it would be 75° at the bottom of the shaft.

This is no doubt caused by the large quantity of air passing into the workings.

The air, on arriving at the bottom of the down-cast shaft, descends the main brow into the Rams mine, and as it travels it increases in temperature in accordance with the depth under the surface, until it arrives at the lowest level at 625 yards from the pit, and at that point is 738 yards below the surface of the ground, where it is 78°.

The air then proceeds along the west level for a distance of 930 yards, and in passing the new openings or levels still further increases to 79° at the face of level.

This high temperature above the one of the returns at the upcast shaft, is due to the amount of heat given off by the new opening, and which is afterwards cooled by the slight leakages and mixing with the other returns before it arrives at the upcast shaft.

The air in this place has to travel about 4,000 yards, and gets reduced in temperature to 72° at the upcast shaft.

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In ascertaining the normal temperature of coal or strata, the temperature should be taken immediately after the level or tunnel has been driven, and close to the face, because the heat is given off so very rapidly, and if there is a good ventilation it will soon cool a degree or two.

The holes in which the thermometers have been placed have varied from three feet to twelve feet deep, and have remained inside varying from twenty minutes to eight hours, but no appreciable difference has been noticed.

The great question to be solved in mining is the probable distance we can work our minerals below the surface, and what heat can workmen endure without doing themselves a very serious injury.

We all know that if we get above 98°, which is blood-heat, that some change must take place in the ordinary state of a man who has to work in it, so that he can endure; and the natural inference is, that he cannot do as much work as at a less heat, or he must use extraordinary means to enable him to do so.

The object, therefore, should be to bring into action such an amount of ventilation into the mines as will cool down and carry away the heat as it is given off; and this can only be done by a large area of shafts, and large or numerous airways.

It has thus been shown that as the air travels into deeper and more extended workings, it gets surcharged with the heat of the strata; and it also shows that if we bring a large current of air to bear upon it, the temperature is gradually reduced in accordance with the length of time they are opened.

This will also apply to the strata itself; for it is found that if the ventilation is continued, and the longer the airways are opened, the strata gradually cools; but if the ventilation diminishes or ceases, no doubt the strata would soon return to its former heat.

On referring to the temperatures taken on the 28th February, 1870, in the same places as those taken on the 30th of March, 1868, it will be observed that there has been a diminution of 4° in the No. 3 and No. 4 levels, near to the engine brow, and that the diminution lessens in accordance with the distances on the level and length of time the workings have been opened, until we arrive at the face of the level where the temperature agrees with the other parts of the mine when they were first opened, at the same depth from the surface.

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Another means of cooling the air going into the mines may be by saturation with water; but this, probably, if carried on to a large extent, would injure the roadways, by causing the sides and roofs to give way, and in the end impede the current.

It is quite possible this saturated air would be more injurious for the men to work in than a warmer and drier air, for we find that a person can endure longer the heat of the torrid zone and the cold of the frigid zone, where the air is drier, than in our temperate zone, where there is a much larger amount of moisture.

There is one difficulty which will always arise and take time to counteract, viz.,—the exploring drifts. The air in these will naturally be somewhat similar to the strata at the time they are being worked; but it is possible to overcome this, by specially bringing to bear on that part an extraordinary current of air, or make use of the exhaust air of the coal cutting or holing machines, which, no doubt, will gradually take their places in the requirements of mining.

With regard to these machines, it is known that, in compressing air, a very large quantity of heat is given off, because the heat retained is only in proportion to the bulk; so that the more the air is compressed the larger the quantity of heat is given off, and, when this compressed air is brought to the coal cutting or holing machine in the exploring workings, the exhaust air will be of the greatest service in assisting to reduce the temperature of the air in the new openings.

It has been observed that if there is any moisture about the exhaust pipe, it is soon converted into ice.

Another point to take into consideration will be the greater tendency for coal to give off gas in larger quantities as we get deeper, and in doing this it is possible that the heat may be given off more rapidly, and in a much shorter space of time will cool down to an ordinary temperature. In the cooling down of strata it can only be expected to take place and continue in the reduced state so long as the air is constantly allowed to traverse the workings; and as any unnecessary length of current of the air would materially add to the difficulty of ventilating a mine well, it is very desirable that these currents should be shortened as much as possible, and avoid carrying air into any place which is not absolutely required.

When the current of air is taken off any old workings, the strata

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will soon return to its ordinary normal temperature, in accordance with the distance from the surface.

In the preparation of a paper on this subject, it brings very forcibly to the mind the difficulties managers of collieries have to contend with in the deeper and more extended workings; and it is only by increased skill and perseverance these can be overcome.

There are the three great elements of nature, Fire, Air, and Water. Each in their respective qualities require carefully manipulating, and can be made exceedingly useful; but, on the other hand, if any one of them obtains the mastery over the skill of the manager, then we can only look forward to enormous outlays and losses, including no ordinary risk to those who are engaged in the undertaking.

The working of a colliery is at the best of times a dangerous employment; and those who have any connection with them cannot help feeling that persons who are so fond of writing letters to and leading articles in the newspapers against the management of collieries, are not aware of the difficulties, dangers, and risks of the men who have charge of them, and the men working far below the surface of earth, to produce that valuable mineral which has been placed there for the benefit, comfort, and luxury of mankind.

On the motion of Mr. Binney, seconded by Mr. Greenwell, the thanks of the Society were awarded to Mr. Knowles for his communication.

The Chairman: I shall be glad if any gentleman present, practically acquainted with mining operations, will give us their opinions on the subject which Mr. Knowles has introduced.

Mr. Greenwell: One point which struck me in the paper was, that of the temperature at the top of the downcast shaft being 68°, and at the bottom of the shaft 67°. Considering that the natural temperature of strata is rather hotter at some distance below than at the surface, I can only account for this apparent variation from the usual condition of things in some such way as this. On the day when the test was made there may have been no wind at the surface, and the temperature taken would be that of still air; on the other hand, when the temperature was taken at the bottom of the shaft,

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there may have been a little moisture on the bulb of the thermometer, and the rapid current of air passing might produce a little diminution. I can see no other way of accounting for the fact stated. Ninety-two thousand cubic feet of air going through ten feet space would be moving at a very rapid rate, and that, if there was any moisture on the bulb, would have a tendency to rather lower the recorded temperature.

The Chairman: Might it not arise from the pressure being reduced at the bottom of the shaft?

Mr. Greenwell: It would be the contrary; because the air itself being under greater pressure at the bottom than at the top of the shaft, its capacity for heat would *diminish*.

The Chairman: If the air were still it would be as you state, but when moving rapidly through, and being drawn by artificial means in another shaft, I doubt whether that would be the result.

Mr. Greenwell: I think the barometer at the bottom of a shaft would indicate one *inch* for every thousand feet additional.

Mr. Knowles: In this particular case, the temperature was taken on the 5th of June, a very hot day.

Mr. Binney: Has Mr. Knowles tried the temperature of water that there may be in any newly-opened levels.

Mr. Knowles: The water has not been tried.

Mr. Binney: Water gives you about the best estimate of temperature that you can get at.

Mr. Knowles: The main point is the temperature of the strata, and that should only be taken at the time a level is driven. If the water is allowed to remain subject to the action of the air, it will soon get to the same temperature as the air.

Mr. Binney: I have seen some wonderful deductions, at so many feet from temperature, both in Cornish and Devon mines, and also in collieries. The observations had generally been taken by men who had hardly ever seen a thermometer before, and the published observations show a remarkable diversity. I have been appointed on a committee who have been requested to get some information about these matters. It was suggested to us that we should have bored holes, and got water from a great depth, say 2,000 feet, to ascertain its temperatures. With re-

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spect to the temperature of mines, it has struck me that, in accounting for increased temperature, you should take into consideration, amongst other matters, the heat from candles and ventilating furnaces, and that proceeding from human bodies where a large number of men are employed.

Mr. Knowles: The heat of the air, not of the measures.

Mr. Binney: The heat would be communicated to the measures. I have no doubt that in new workings the temperature would be greatly reduced by the escape of gas where it had been closely compressed in the coal.

Mr. Greenwell: I think Mr. Binney means that the temperature should be taken in water immediately as it issues out of the strata. When that mode of ascertaining temperature is available, I always adopt it myself.

Mr. Knowles: We have no water at all.

Mr. Greenwell: There is another point which I should like to have discussed a little, viz., whether we have sufficient information at Present to enable us to lay down any law as to the advance in temperature as distributed over a certain number of feet. For instance, if we take the experiments made by Arago in artesian wells, he estimated about one degree of increase for every fifty feet, whilst subsequent experiments in deeper mines show that considerably more than fifty feet must be allowed for a degree of increase. At Monk Wearmouth the increase was one degree for sixty-nine feet, and at Dukinfield one degree for every eighty feet. That would seem to indicate that the temperature does not increase in regular proportion according to the increased depth. I put it to the meeting whether it is to be taken that we have sufficient data to enable us to determine what the temperature will be as we go deeper? I do not think we have.

The Chairman: That question has been attempted to be answered by Mr. Hull, of the Geological Survey, who tries to show that the temperature at a given depth depends on the position of the strata as well as its character. He thinks that where the direction of the strata approaches the perpendicular, the temperature will be kept at a lower level than where the direction is horizontal; as, in the latter case, the heat, to escape, would have to pass through strata of various

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densities and characters, and would consequently get away with less facility than it could travel along strata cropping out at the surface. Whether that is a satisfactory answer or not, scientific men must judge.

Mr. Greenwell: I think one point in Mr. Knowles's paper is scarcely borne out by experience in other places, and that is the assumed tendency of coal to give off gas in larger quantities the deeper you go. There is, for instance, the case of two collieries on the Tyne, both working the same seam of coal—one at Jarrow, where the seam is 170 fathoms, and another at Monk Wearmouth, where the seam is 270 fathoms; and yet, at Jarrow, the seam was the most fiery ever worked, whilst at Monk Wearmouth, 100 fathoms deeper, there was scarcely any gas.

Mr. Binney: There is no accounting for the presence or non-presence of gas. I know whole coalfields in Scotland where there is no trace of it.

Mr. Knowles: We find that we get more gas as we go deeper—the gas is much more compressed. Probably one of the fields just mentioned was a maiden field, and the other not. What I mean is that we get more gas as we go deeper in the same mine.

Mr. Binney: I don't think you have a greater temperature where you have a greater amount of gas—that is, an increase of temperature in accordance with the quantity of gas.

Mr. Knowles: I do not say that.

Mr. Binney: The most remarkable instance of which I have any knowledge of gas bursting out at the top of the shaft, was in sinking the Arley Mine at Ince Hall. There it lifted up, through the shaft which they were sinking, an extraordinary quantity of earth, simply owing to the pressure there had been.

Mr. Greenwell: We have been speaking about the increase of temperature as we go below the surface. Now a statement has been made by Mr. George Elliott, that when you go in, as he has the means of doing in South Wales, under, say, a thousand feet of cover, when he gets under that, the temperature is about the same as it is at another place where you have sunk a thousand feet and tested at that depth. That inquiry prosecuted further might bear very hardly on the theory as to the present assumed causes of increased temperature.

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The Chairman: Mr. Knowles has referred to one important consideration. In speaking of the depth at which coal can be worked beneath the surface, he says it is probable machines will ere long be worked by compressed air, which air, being liberated, would reduce the heat, and might enable coals to be secured at a depth where they could not be reached with the ordinary modes of ventilation. I think that will eventually exercise an important influence.

Mr. Greenwell: There is said to be great waste of power by means of compressed air, I believe much of it arises from radiation from the pipes which conduct the air. I believe it is as necessary to clothe pipes for compressed air, as it is to clothe pipes for conducting steam.

The Chairman: Quite as necessary.

This closed the discussion on Mr. Knowles's paper.

The Chairman: I have next to call your attention to a few specimens of silver ore from Nevada, United States. Some of them contain a large proportion of silver. This small one, from the Eberhardt Mine, is especially rich, about one-half of it being pure metal. These others contain it in various proportions. Mr. Moss Fletcher, who lends these specimes, has sent a short account of them which, with your permission, I will read :—

Observations on some Specimens of Silver Ore from the State of Nevada, United States.

BY JOHN MOSS FLETCHER.

The eight specimens of silver ore have been taken out of different mines, principally from those of Treasure Hill, a spur of the White Pine Mountain Range, in the State of Nevada, U.S.A.

The state of Nevada was formerly a part of Utah; but about twenty years ago (1848), when the Americans took California and other lands from the Mexicans, and annexed them to the United States, Utah was divided,—that part of the state nearest to New York, in which is the Mormon city and the Great Salt Lake, retaining its old name; the part adjoining California being called the State of Nevada, taking its name from the range of mountains (the Sierra Nevada)

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which runs through it. The northern part of the state is now traversed by the Central Pacific Railway, which runs from the Atlantic to the Pacific Ocean, is over 3,000 miles in length, and in one part, at Sherman Station, is over 8,000 feet above the level of the sea.

The tract of country lying between the Sierra Nevada and the Rocky Mountains has an altitude of several thousand feet above the sea level, and is called by some travellers the "Great Basin": it is shut in all round by mountains, having its own system of lakes and rivers, which have no connection with the sea.

It is in this basin that the "White Pine" mountains are situated, in latitude 39 deg. north, and 115 deg. west from Greenwich, about 100 miles south of the Central Pacific Railway, and 300 miles south-east of the Salt Lake City, where Brigham Young and his followers are located.

This immense mountain range, portions of which rise above 10,000 feet above the sea, was not even marked on the maps of the United States five years ago; and it is only four years since the first discovery of silver-bearing lodes in this district, and only a little over three years, (namely, in July, 1867,) since an Indian showed a piece of rich ore to a man in the employ of the Monte Christo Company, which he had found on what is now known as "Treasure Hill;" so that this "Treasure Hill" was unknown and nameless in 1867. In 1869 it had been *proved* to be so valuable, that no money could purchase it—one mine alone, the Eberhardt, being valued at £2,000,000 sterling. It is well known that the owners have refused the enormous sum of £1,000,000 in money and securities for it.

On this hill alone there were thirty-three large mines, besides several smaller ones, in work at Christmas, 1868; the official returns show that the amount of ore taken out of them was £300,000 in value, and that 20,000 men were employed in various ways in this hitherto barren and desolate district.

Mr. Clayton, of San Francisco, writing of the geological age, formation, &c., of this celebrated Treasure Hill, says: "It is almost exclusively in Limestone of the Silurian age. The thickness of the Lime strata cannot be determined closely, for the reason that the upheaval and displacement have not brought to light the underlying

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rocks. Sufficient displacement has occured, however, to expose a thickness of about 800 feet of Limestone in beds or strata, varying in thickness from six inches to twenty feet each. The greater mass of Lime Rock has been so much changed by chemical agencies, that the fossils have, in a measure, disappeared, leaving only obscure outlines on the weathered surface; excepting in the upper strata, next to the overlying slates, three or four species of Corallines and a few small Bivalves represent the animal life of the period in which Limestones were formed." *

No. 1.—The richest of these specimens was taken from the "Eberhardt" Mine, in September, 1869. This mine was only located on January 3rd, 1868, and is the property of men who worked in the Monte Christo Mill, in Austin, in 1867. Their property is now almost beyond value; as this mine alone, in the quarter ending December 31st, 1868, yielded 476 tons of ore, which produced £70,000 worth of silver, the average yield being over £150 per ton, 16lbs. of ore being worth 20s. The specimen exhibited is almost pure silver, and was taken out of the mine at a depth of 190 feet from the top. The walls of the vein are of white spar, running east and west, and are nearly perpendicular. They are 183 feet apart, consequently the vein is of this great thickness.

The "Addington" (No. 2), the "Bell Ledge" (No. 3), and the "Davis" Claim (No. 4), specimens are chosen to show the different kind of ores in the district. The Crystallised Spar (No. 5) also comes from the same hill.

No. 6.—The curious blue specimen is from the "Base Metal" mountain range, which is east of Treasure Hill. The ore is not nearly so pure here, being mixed with lead, copper, iron, and antimony.

The specimen (No. 7) is from the celebrated "Comstock" lode,

* Since the above was communicated to the Society, my attention has been directed to the extract of a letter written by F. B. Meek, Esq., of the Geological Survey of Illinois, U.S.A., to Dr. J. J. Bigsby, F.R.S., (Author of the "Thesaurus Siluricus,") which appeared in the April number of the "Geological Magazine" for the present year, from which it appears that he (Mr. Meek) has satisfactorily determined, from the fossil contents and other evidence, that the great silver-bearing rocks of the White Pine mining district in the State of Neveda belong to the Devonian formation, though the Carboniferous is also well developed there.

As this conclusion has been arrived at by Mr. Meek after careful and protracted observation, the opinion of that gentleman is entitled to the fullest consideration and respect.—JOHN AITKEN, Bacup, 12th April, 1870.

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Virginia City, Nevada. This lode was found by a poor man, who sold it for a horse; it has yielded £100,000 a year for several years.

The 8th specimen is from the "Blue Eagle" Mine in the Troy district, seventy-five miles south of Treasure Hill. These ores are precisely similar to those on Treasure Hill; and there are strong reasons for concluding that these mines are another outcrop of the same strata, as the ores are pure chlorides, those near Virginia city being sulphate, and require to be roasted in addition to the process the chlorids have to go through.

Ore from this mine has been assayed by Messrs. Johnson, of Hatton Garden, London, and proves to be exceedingly rich, giving over "nine" ounces of pure silver to the hundredweight of ore, and being worth about £40 per ton of rough ore.

The piece of pure silver has been extracted from 14lbs. of this ore, and weighs $1\frac{1}{6}$ oz.

On the motion of Mr. Greenwell, seconded by Mr. Hardwicke, the thanks of the Society were given to Mr. Fletcher for his communication, and to the Chairman for reading it.

The Chairman: Mr. Fletcher is to a certain extent interested in some of these mines. As he had the specimens at Bacup, I asked him to allow me to make use of them. He has kindly done so, and written this short account, which I have read. There can be no doubt that the district in question is an extraordinary one, and extremely rich in argentiferous ores.

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